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In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

TRITIUM IN SURFACE WATERS, 1964–1965

M. W. Chesnutt, J. C. Drobinski, Jr., and R. H. Gorrie [1]

SYNOPSIS—Concentrations of tritium in U.S. surface waters are reported for the period of May 1964 through December 1965. This is the initial report of a continuing surveillance program. The results show some differences in tritium concentrations in water samples from various parts of the country and as a function of time. The highest level observed (20.3 nCi/liter) is well below the occupational exposure guide (30 μCi/liter) and the guidance level requiring active surveillance (100 nCi/liter), calculated from the general guidance of the Federal Radiation Council.

Tritium occurs naturally in the environment as a product of cosmic ray bombardment of the upper atmosphere (*1–4*). Man has introduced tritium into the environment as a product of nuclear fusion (*5*), tritium manufacturing plants, and as a product of ternary fission in reactors (*6, 7*). Due to the relatively long half-life (12.26 years) of tritium and its potential radiological health implications, the Division of Radiological Health, Public Health Service, has established a modest surveillance program to determine concentrations of tritium in selected surface waters. This report presents the initial data from this program.

From the occupational exposure guide of 30 μCi/liter (*8, 9*) and using general guidance from the Federal Radiation Council (*10–12*), the concentration of tritium in water which requires active surveillance can be calculated to be 100 nCi liter.

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PRELIMINARY STUDIES

During 1963, a preliminary study was conducted to determine the levels of tritium in raw and treated waters collected through the Water Pollution Surveillance Program of the Division of Water Supply and Pollution Control[2] and by the Institutional Total Diet Sampling Program of the Division of Radiological Health. Tritium levels were determined in additional samples collected upstream and downstream from the Atomic Energy Commission Savannah River Plant (*13*). Observed tritium concentrations in surface waters varied from less than detectable to 12 nCi/liter.

PRESENT PROGRAM

Sampling stations

Based on the preliminary findings and reports from other studies, a surveillance program was established in May 1964 to monitor tritium concentrations in major river systems in the contiguous United States. Ten stations were selected from existing water pollution

[2] In January 1966, this program was designated as the Basic Data Branch, Federal Water Pollution Control Administration, Department of the Interior.

surveillance sampling stations in order to obtain coverage of major river basins. Eight of these stations are located downstream from nuclear facilities. Two stations serve to establish baseline levels (figure 1).

Analytical methods

Thirty-milliliter aliquots,[3] or greater, from 1-liter monthly composites of weekly samples collected from the water pollution surveillance stations are shipped to the Northeastern Radiological Health Laboratory (NERHL) or Southeastern Radiological Health Laboratory (SERHL) for analysis.

Both the NERHL and SERHL process samples in the liquid form using various adaptations of liquid scintillation counting techniques, and NERHL utilizes electrolysis cells to enrich the water in tritium.

At the NERHL, a sample is distilled to dryness from a slightly alkaline potassium permanganate solution. An aliquot of the distillate is concentrated approximately 25-fold by electrolysis (*14*). An aliquot of this enriched water is mixed with a scintillation mixture of p–dioxane, dimethoxyethane, naphthalene, 2, 5–diphenyloxazole, POP, (scintillation grade) and 1, 4–bis–2–(5–phenyloxazolyl)–benzene, POPOP, (scintillation grade) and counted in a liquid scintillation counter. The minimum level of detectability is approximately 0.1 nCi tritium/liter for a 100-minute count.

At the SERHL, a sample is distilled to dryness and an aliquot of the distillate is mixed with a scintillation mixture of p–dioxane, naphthalene, 2, 5–diphenyloxazole (scintillation grade) and 1, 4–bis–2–(5–phenyloxazolyl)–benzene (scintillation grade). The sample is then counted in a liquid scintillation counter (*15*). The minimum level of detectability is approximately 1.2 nCi tritium/liter for a 240-minute count.

The sensitivity of these methods is considered adequate for environmental surveillance purposes in relation to the calculated guidance level.

Results and discussion

Results of the analyses of the 1964 and 1965 surveillance program water samples are presented in table 1. The samples from Georgia, Tennessee, Ohio, and Pasco, Washington, were analyzed at the SERHL and samples from

[3] NERHL received 500-ml portions.

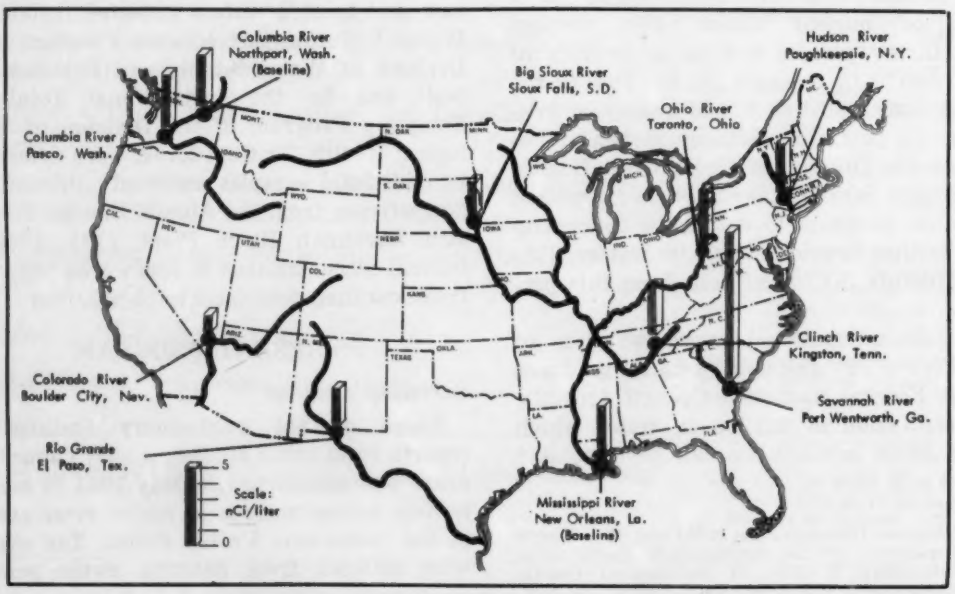

Figure 1. Sampling stations for the Tritium Surveillance Program

Table 1. Tritium in surface waters from 10 sampling locations in the United States

Composite collection date	Tritium concentrations, nCi/liter [a]									
	Big Sioux River: Sioux Falls South Dakota	Clinch River: Kingston Tennessee	Colorado River: Boulder City Nevada	Columbia River: Northport Washington [c]	Columbia River: Pasco Washington	Hudson River: Poughkeepsie New York	Mississippi River: New Orleans Louisiana [c]	Ohio River: Toronto Ohio	Rio Grande: El Paso Texas	Savannah River: Port Wentworth Georgia
1964										
May	4.0±0.4	3.7±2.1	1.7±0.8	1.9±0.7	2.9±2.1	2.2±1.1	2.3±2.0	4.3±2.2	[b] 1.9±2.1	4.1±2.1
June	2.6±0.7	3.2±2.1	1.2±0.9	2.2±1.1	1.4±2.0	3.1±1.2	2.3±2.0	4.4±2.1	3.7±2.1	20.3±2.4
July	3.6±0.9	2.8±2.2	1.3±0.5	3.6±0.7	5.2±0.2	NS	3.4±2.1	2.8±2.1	3.8±2.1	8.1±2.2
August	2.6±0.6	[b] 2.0±2.0	[b] 0.5±0.9	5.8±0.8	2.3±2.0	5.0±0.9	[b] 0.8±1.9	[b] 1.4±2.1	2.7±2.0	6.9±2.1
September	2.5±0.6	2.9±1.9	0.6±0.4	4.0±0.6	6.0±1.9	3.3±0.9	[b] 0.9±1.9	3.8±1.9	[b] 0.8±1.8	6.8±1.9
October	1.3±0.5	6.7±1.9	1.2±0.7	3.6±0.3	3.9±1.9	3.7±0.5	[b] 1.8±2.0	2.4±1.9	[b] 1.1±1.8	9.0±2.0
November	1.0±0.3	4.3±1.8	1.2±0.4	3.4±0.5	4.3±1.8	3.2±0.4	[b] 0.7±1.6	4.0±1.8	[b] 0.8±1.7	4.3±1.8
December	[b] 0±2.8	[b] 1.2±1.7	1.0±0.4	2.6±0.5	3.1±1.8	3.0±0.2	[b] 0.7±1.6	1.8±1.7	[b] 1.0±1.7	3.1±1.8
1965										
January	1.4±0.5	1.9±1.7	1.4±0.6	[b] 0±3.9	7.5±1.8	1.6±0.4	[b] 1.6±1.8	[b] 1.7±1.8	2.6±1.7	4.3±1.8
February	[b] 0±3.6	2.0±0.9	[b] 0±3.6	[b] 2.6±3.6	2.5±0.8	[b] 1.1±3.6	1.2±0.9	2.4±0.9	[b] 0.4±0.9	5.1±0.9
March	[b] 0±3.9	6.5±1.8	[b] 0±3.9	[b] 0.1±3.9	5.1±1.7	[b] 0±3.9	3.6±1.7	3.2±1.8	2.8±1.7	9.5±1.8
April	[b] 2.7±3.8	3.0±1.8	[b] 0±3.4	[b] 2.6±3.6	5.0±1.8	[b] 3.3±3.4	5.0±1.8	4.1±2.0	2.9±1.8	8.3±1.8
May	[b] 0.8±3.9	NS	[b] 2.5±3.6	[b] 2.9±3.6	3.3±2.4	[b] 1.7±3.4	3.6±2.4	3.6±2.4	[b] 1.0±2.4	9.1±2.5
June	1.8±1.1	2.4±1.3	[b] 2.3±3.0	1.2±0.9	3.0±1.3	[b] 2.6±3.0	1.6±1.3	[b] 3.0±1.3	[b] 1.2±1.2	4.8±1.3
July	[b] 0.8±1.4	2.7±1.1	1.5±1.4	4.6±1.4	3.3±1.0	3.6±1.4	[b] 0.8±1.0	NS	[b] 0.5±1.0	10.8±1.2
August	[b] 0.4±1.3	[b] 1.0±1.4	[b] 0.7±1.9	2.5±1.4	[b] 0.3±1.3	3.0±1.4	[b] 0.5±1.5	1.7±1.4	2.4±1.4	6.7±1.1
September	4.7±1.5	5.7±1.5	4.1±1.5	7.9±1.5	4.0±1.5	3.8±1.5	2.3±1.5	8.1±1.5	4.2±1.5	9.6±1.5
October	2.0±1.5	1.9±1.6	3.0±1.6	1.9±1.5	3.1±1.5	3.0±1.6	[b] 0.9±1.5	1.6±1.5	[b] 1.2±1.2	17.1±1.7
November	[b] 0.7±2.2	[b] 0.7±1.7	2.7±1.8	3.0±1.6	[b] 1.4±1.8	[b] 0.9±1.9	[b] 0.5±2.0	[b] 0.8±1.8	[b] 0±2.0	12.2±2.0
December	3.0±2.1	[b] 1.4±1.7	2.3±2.0	[b] 1.4±2.6	6.1±2.1	3.2±1.9	[b] 0.5±2.1	2.0±2.2	0±2.0	14.0±2.2

[a] The error reported is the counting error at 95 percent confidence level.
[b] Values are not statistically significant at 95 percent confidence level.
[c] Baseline station.
NS, no sample

Nevada, New York, South Dakota, and Northport, Washington, were analyzed at the NERHL during May 1964–June 1965. From July to December 1965, all samples were analyzed at the SERHL. For quality control purposes, aliquots of the monthly samples collected during the period of May 1964–June 1965 from El Paso, Texas, and New Orleans, Louisiana, were analyzed by both laboratories.

Differences in tritium content among the sampling stations were anticipated, based on previously reported geographical and meteorological variations in natural tritium levels (*4*). These differences are shown in figure 2. The highest concentration observed for 1 month was 20.3 nCi/liter, which is well below the occupational exposure guide (30 μCi/liter) and the guidance level requiring active surveillance (100 nCi/liter), calculated from the general guidance of the Federal Radiation Council. Although the concentrations observed at the stations vary significantly, there is no indication that the water from stations downstream from nuclear facilities, with the single exception of Port Wentworth, Georgia, has higher levels of tritium than those observed at baseline stations.

Although the results of this program indicate that, at the present time, tritium levels in the environment do not suggest immediate public health implications, the Public Health Service is maintaining surveillance on a modest scale with provisions for an increased program if the need arises.

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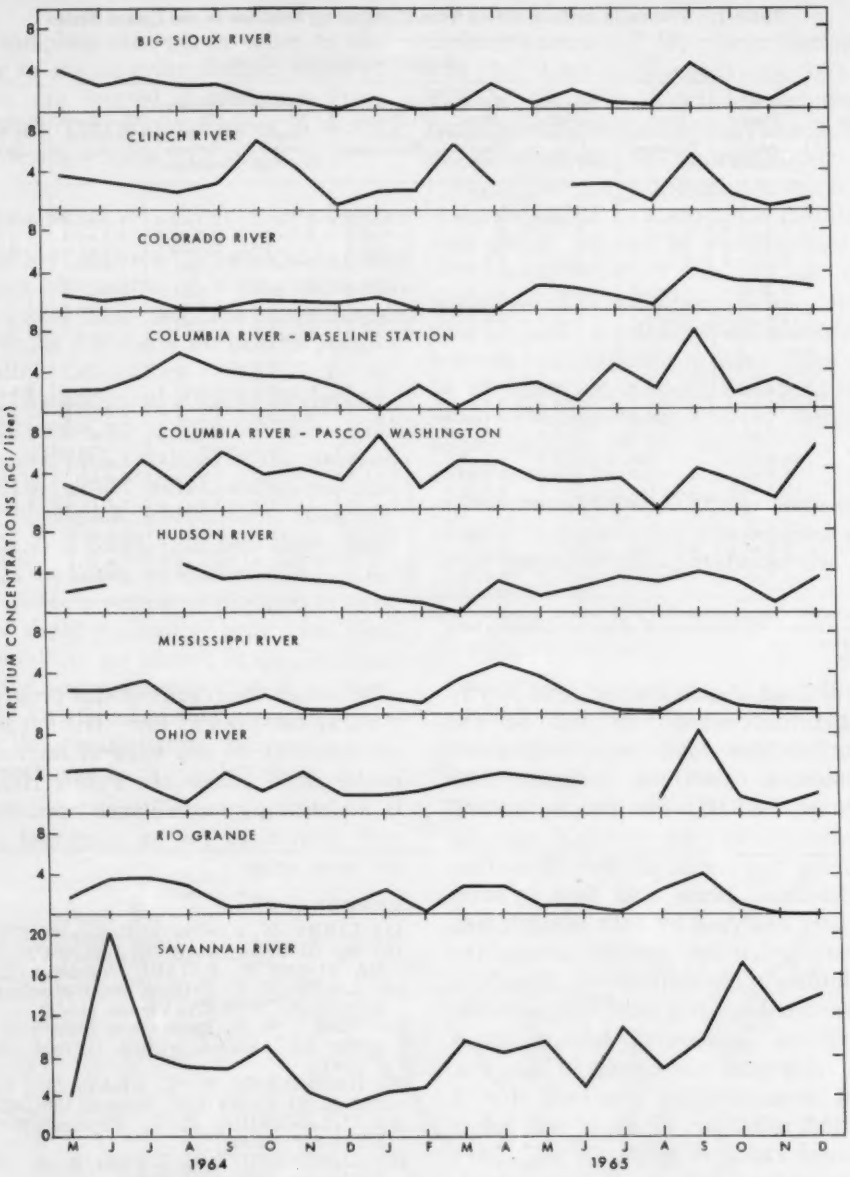

Figure 2. Tritium in surface waters from 10 U.S. sampling locations, 1964–1965

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STRONTIUM-90 IN 1965 UNITED STATES WHEAT

R. A. Anderson and *V. F. Pfeifer*[1]

SYNOPSIS—In continuing surveys of strontium–90 levels in wheat, USDA studies indicate the U.S. weighted average concentration to be 95 pCi/kg, which compares well with the Federal Radiation Council's prediction for 1965 (88 pCi/kg). The 1965 average also confirms the predicted continuing downward trend seen in 1963 and 1964 averages—220 and 133 pCi/kg, respectively. Samples used to develop the 1965 average represented 52 percent of the U.S. wheat production and individual strontium–90 concentrations ranged from a low of 31 pCi/kg, in a soft white winter wheat from Washington, to a high of 174 pCi/kg in hard red winter wheat from Kansas. It was noted that the 1965 trends of high and low concentrations were similar to those of 1964.

As part of studies on methods for reducing the strontium–90 content of wheat and milled products the USDA's Northern Regional Research Laboratory is continuing to survey strontium–90 levels in U.S. wheats from major producing areas. Strontium–90 levels reported for the 1963 and 1964 crops averaged 220 and 133 pCi/kg (dry basis) for the two respective crop years (*1*, *2*).

In general, samples from the 1965 harvest were representative mixes of varieties grown in 14 different locations in seven wheat-producing States. These areas represent about 52 percent of the total of 1965 wheat production (*3*). The analytical procedures used have been described previously (*2*).

The results listed in table 1 show lowest levels of strontium–90 in wheat from Washington and North Dakota, and the highest from Kansas and Nebraska. Individual values range from a low of 31 pCi/kg (dry basis) for soft white winter wheat grown in Washington, to a high of 174 for a hard red winter wheat mix grown on dry land in Garden City, Kansas. In 1964, the high and low levels of strontium–90 occurred in wheat from these same areas. Furthermore, Ottawa variety of hard red winter wheat had the highest strontium–90 content in 1964, 380 pCi/kg (dry basis); and this high level continued in 1965; a sample of Ottawa wheat harvested in Douglas County, Kansas had strontium–90 content of 166 pCi/kg.

Although sampling in 1965 was not quite so complete as in 1964 with respect to areas covered, it is believed that it is adequate to permit a reasonable estimate to be made of average strontium–90 content in 1965 wheats. If State averages are estimated by averaging the corresponding local values (table 1), and if each State average is weighted according to the ratio of 1965 wheat production in that State to the total 1965 crop, the U.S. average is 95 pCi/kg (dry basis). This estimate compares well with the Federal Radiation Council's predicted average value of 88 pCi/kg (dry

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Table 1. Analyses of U.S. wheats harvested in 1965 [a]

Wheat class	Grown in vicinity of	Number of samples	Nitrogen (percent)	Ash (percent)	Calcium (percent)	Strontium-90 (pCi/kg)
HRW [b]	Peoria, Ill.	1	2.35	2.08	.054	84
HRW	Douglas County, Kans.	1	2.80	2.00	.058	166
HRW	Newton, Kans.	[f] Mix	2.44	1.94	.056	133
HRW	Manhattan, Kans.	12	2.65	1.60	.044	82
HRW	Garden City, Kans. (Dry land)	Mix	3.01	2.16	.058	174
HRW	Garden City, Kans. (Irrigated)	Mix	2.97	2.17	.055	158
HRW	Hays, Kans.	13	2.54	1.72	.049	157
HRW	Alliance, Nebr.	Mix	1.92	1.85	.052	95
HRW	Lincoln, Nebr.	Mix	2.63	2.04	.064	147
HRS [c]	Carrington, N. Dak.	Mix	2.99	1.85	.033	53
HRS	Minot, N. Dak.	Mix	2.63	1.90	.036	52
SRW [d]	Huntington, Ind.	2	2.17	1.88	.047	98
SWW [e]	Breckenridge, Mich.	1	2.17	1.49	.042	82
SWW	Pullman, Wash.	6	1.29	1.38	.048	31
SWW	Rosalia, Wash.	1	2.31	1.87	.038	67

[a] Calculated on a dry basis where the wheat moisture contents varied from 9.4 to 12.7 percent.
[b] HRW indicates a hard red winter wheat.
[c] HRS indicates a hard red spring wheat.
[d] SRW indicates a soft red winter wheat.
[e] SWW indicates a soft white winter wheat.
[f] Representative mixture of an undisclosed number of different wheat varieties grown in immediate area.

basis) for 1965 U.S. wheat and confirms its prediction of a continuing downward trend in strontium–90 levels in wheat (*4*).

Acknowledgments

We acknowledge the cooperation of the following stations, firms, and individuals in supplying the samples of 1965 wheat: Agricultural Experiment Stations at Newton, Manhattan, Garden City, and Hays, Kansas, and at Lincoln and Alliance, Nebraska; Western Wheat Quality Laboratory, Pullman, Washington; Loon Creek Valley Farms, Huntington, Indiana; B&W Cooperative, Breakenridge, Michigan; Rosalia Producers, Inc., Rosalia, Washington; Klindworth Seed and Supply, Carrington, North Dakota; Peavey Company, Minot, North Dakota; and J. E. Hubbard, Northern Laboratory, Peoria, Illinois.

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STRONTIUM-90 IN HUMAN BONE FROM INFANCY TO ADULTHOOD 1962–1963

George W. Gaffney,[1] *Robert M. Hallisey,*[2] *Marshall S. Miller,*[1] and *Edmond J. Baratta*[2]

SYNOPSIS—Strontium–90 accumulation in the bones of children and adults through age 25 is analyzed by comparing the strontium–90 to calcium ratios found in specimens from selected age groups during the 1962–1963 portion of a continuing program. The highest mean strontium–90 to calcium ratios were found in the 1- to 4-year olds, with the 1962 peak in the 1-year olds (4.5 pCi/g) and the 1963 peak in the 2-year olds (5.6 pCi/g). It is pointed out that the mean values for the group under 1 year of age were relatively low (2.6 pCi/g in 1962; 1.8 pCi/g in 1963), but were obtained from a small number of samples. Average strontium–90 to calcium ratios in bone of older groups declined with increasing age and were least in the 20- to 25-year-age group. The data for each age group, although limited, appear to follow a log normal distribution, and it is suggested that this distribution is more suitable than a normal distribution as a basis for calculating the proportion of a population group in which a given body burden is unlikely to be exceeded.

The Public Health Service's Division of Radiological Health and cooperating institutions continue to gain information on the accumulation of selected radionuclides in people based on direct measurements in human organs and tissues (*1*). A previous report included results from the strontium–90 in human bone program through June 1964; it analyzed the data available at that time from 322 individuals who died in 1962 or 1963 (*2*). Subsequently, the results of 117 specimens and replicate measurements of previous samples were reported (*3, 4*). This report is an analysis of the information on a total of 439 individuals who died in 1962 and 1963 at an age of not more than 25 years.

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[2] Mr. Hallisey is project officer of the Human Bone Network, and Mr. Baratta is director of Analytical Services, Northeastern Radiological Health Laboratory, 109 Holton Street, Winchester, Massachusetts 01890.

Materials and methods

The program employs sampling procedures designed to exclude bone samples from individuals manifesting certain nutritional deficiencies or disorders of calcium metabolism. Laboratory procedures have been described in a previous report (*5*).

Results

The data on strontium–90 to calcium ratios are summarized in 1-year-age groups for ages through 4 years, and in four age ranges for specimens between 5 and 25 years of age at death. The number of individuals in each age category, the median and mean strontium–90 to calcium ratios in bone, and the standard error of the mean for each age group are shown in table 1.

Table 1. Strontium-90/calcium ratios in human bone samples from selected deaths in the United States in 1962–1963

Age group (years)	1962 Ratios, pCi/g				1963 Ratios, pCi/g			
	Number of samples	Median	Mean	S.E.[a]	Number of samples	Median	Mean	S.E.[a]
<1	15	1.9	2.6	0.46	5	1.3	1.8	0.45
1	9	3.7	4.5	0.90	4	4.2	4.7	1.09
2	11	2.9	3.9	0.58	9	5.2	5 6	0.95
3	5	3.2	3.1	0.33	11	4.8	5.3	0.70
4	10	2.5	2.6	0.24	15	3.9	4.1	0.41
1–3	25	3.2	3.9	0.42	24	4.8	5.3	0.51
1–4	35	3.0	3.6	0.32	39	4.1	4.8	0.38
5–9	33	2.3	2.7	0.32	43	3.7	3.9	0.22
10–14	28	2.0	2.1	0.18	47	2.6	2.9	0.20
15–19	31	2.0	2.2	0.15	73	2.5	2.6	0.11
20–25	29	1.8	1.8	0.13	61	2.1	2.2	0.10
All ages	171				268			

[a] One standard error of the mean.

Data in figure 1 and table 1 suggest that a "peak" value for strontium–90 to calcium in the bone samples from deaths in 1963 probably occurred in the 2-year-age group. The mean value for this group was 5.6 pCi/g, which may be compared with 1.8 for the <1-year group and 2.2 for the 20- to 25-year group. The "peak" mean strontium–90 to calcium for bone from 1962 deaths (4.5 pCi/g) occurred in the 1-year-old group; the corresponding value in the 2-year-old group was 3.9 pCi/g. The number of samples in each of the 12-month categories was small, however, and the "peaks" for both 1962 and 1963 may actually have spanned more than 1 year of age. The latter view appears consistent with the observation from table 2 that the 1962 mean and median strontium–90 to calcium ratios are similar for the 1-, 2-, and 3-year-old groups, and somewhat less for the 4-year-old group. For children in the 1- to 4-year-age range in 1962, the strontium–90 to calcium ratio was 1.7 to 2.0 times that observed in the adult group. A similar relationship was observed in the strontium–90 to calcium ratios for 1963, except that the changes with age were more gradual. For 1963 the greatest mean and median strontium–90 to calcium ratios occur in the 2-year-old group. The average strontium–90 to calcium ratio for the 1-year through the 5- to 9-year-old groups was about twice that found in the 20- to 25-year-old group. The observations seem consistent with the contention that the "peak"

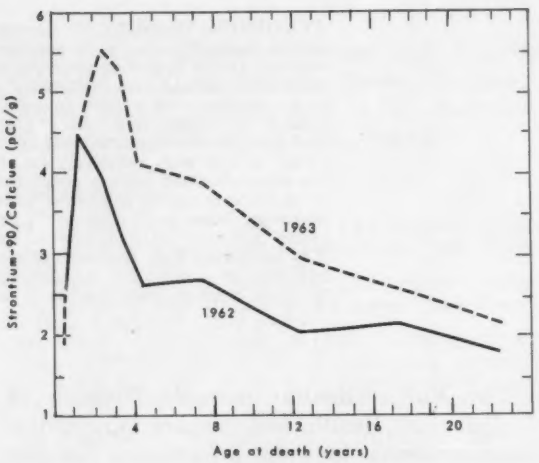

Figure 1. Mean strontium–90 to calcium ratios in samples of human bone from individuals who died in the United States in 1962 and 1963

Table 2. Ratio of strontium-90 to calcium in bone for various age groups to the strontium-90 to calcium in bone for the age group 20 to 25 years

Age group (years)	Ratio, 1962		Ratio, 1963	
	From median	From mean	From median	From mean
<1	1.0	1.5	0.6	0.8
1	2.1	2.5	2.0	2.1
2	1.6	2.2	2.5	2.6
3	1.8	1.7	2.3	2.4
4	1.4	1.4	1.9	1.9
1–4	1.7	2.0	2.0	2.2
5–9	1.3	1.5	1.9	1.8
10–14	1.1	1.2	1.2	1.3
15–19	1.2	1.1	1.2	1.2
20–25	1.0	1.0	1.0	1.0

strontium–90 to calcium in bone will gradually move through increasingly older age groups up to adulthood provided that the strontium–90 to calcium ratio in the diet remains constant or decreases from concentrations existing in 1963.

Attention was called to the skewness in the distribution of strontium–90 to calcium in bone, which was skewed due to a relatively small number of high values (*2*). It was further shown that the plotting on log probability paper of strontium–90 to calcium in bone for each age group in 1963 data (table 1) produced a straight-line fit, characteristic of a log normal distribution (figure 2). To the extent that the bone sampling reflects the distribution of strontium–90 in population groups, the number of individuals whose body burdens might exceed a given value might thus be underestimated if a normal distribution is assumed. As a basis for the calculation of the proportion of a population group in which a given burden is unlikely to be exceeded, assumption of a log normal distribution appears preferable to that of a normal distribution. All of the strontium–90 to calcium data for deaths in 1963 only were used in figure 2.

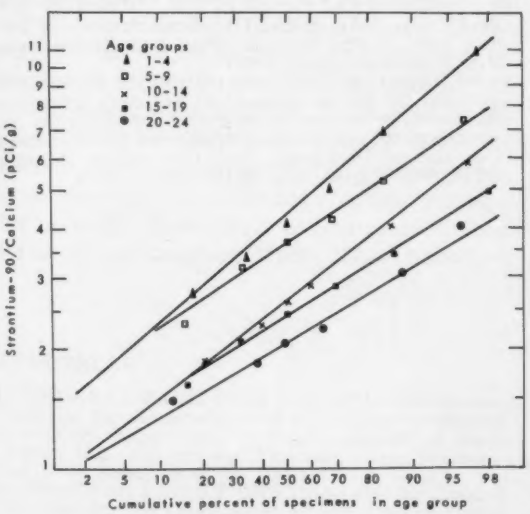

Figure 2. Log-probability plots of strontium–90 to calcium ratios in samples of human bone from individuals who died in the United States in 1963

In table 3, the 95th or 98th percentile value for strontium–90 to calcium in bone for each age group for 1963 was divided by the median (50th percentile value) for the group. Such ratios and the 50th percentile values may be used to calculate the strontium–90 to calcium values in bone for a specified percentage of individuals in a population group. For example, for 1963 and for individuals in the 1- to 19-year-age group at or above the 95th percentile, the strontium–90 to calcium may be calculated to be $\geq 3.3 \times 1.9$; *i.e.*, 6.3 pCi/g or more.

Table 3. Comparison of the 95th and 98th percentile strontium-90 to calcium values with the median (50th percentile) in bone from various selected ages at death in the United States in 1963

Age group (years)	Median value strontium-90/ calcium (pCi/g)	Ratio of the 95-percent to median value	Ratio of the 98-percent to median value
1–4	4.3	2.1	2.6
5–9	3.6	1.9	2.2
10–14	2.7	2.0	2.4
15–19	2.5	1.7	2.0
20–25	2.1	1.7	2.0
1–19	[a] 3.3	1.9	2.3

[a] Average of four groups

Discussion

The results given in table 1 and figure 1 suggest that the bone burden of strontium–90 in the age group less than 1 year may be substantially less than the bone burden for age groups 1-4, 5-9, 10-14, and 15-19 in a decreasing order, for both 1962 and 1963. The <1-year group did not include specimens from stillbirths. It is postulated, however, that the strontium–90 to calcium in stillbirth specimens would be substantially lower than that of specimens in the 1-4-year group and, hence, data on stillbirth specimens, which may be collected with relative ease, must be interpreted with extreme care if used to predict bone burdens of strontium–90 in children.

Assuming a linear proportionality of 1 nCi strontium–90/g bone calcium being equivalent to a yearly dose of 0.9 rads (*6*), then the maximum dose for 98 percent of the individuals in the age group of 1 to 4 years would be (from table 3) $4.3 \times 2.6 \times 0.9$, or 10 millirads per year, as compared to the Radiation Protection Guide (*6*) of 170 millirads/year.

Summary

The bone samples, which totaled 171 for 1962 and 268 for 1963, were arranged into six

major and four minor age categories from less than 1 year to the adult group of 20 to 25 years of age.

In a rather limited number of samples available in the 12-month categories less than 5 years of age, the mean strontium–90 to calcium ratio was highest in the 1-year group in 1962 (4.5 pCi/g) and in the 2-year group in 1963 (5.5 pCi/g).

The average strontium–90 to calcium in bone of older groups decreased progressively (slope decreasing with increasing age) and was least in the adults of the 20- to 25-year group (1.9 pCi/g in 1962 and 2.2 pCi/g in 1963). The mean strontium–90 to calcium for the small number of samples in the youngest age group (<1 year) was only 2.4 pCi/g for 1962 and 1.8 pCi/g for 1963.

The data definitely suggest that interest in strontium–90 in human bone, for 1962 and 1963 at least, should be directed to the 1- to 4-year-age group. It is emphasized that the low values in the <1-year group, when combined with the 1- to 4-year-old group, may result in underestimating burdens in the latter range.

The data, although limited, appear to be characteristic of a log normal distribution in each age group. To the extent that the bone sampling reflects the distribution of strontium–90 in population groups, the number of individuals whose body burden might exceed a given value might thus be underestimated if a normal distribution is assumed. As a basis for the calculation of the proportion of a population group in which a given burden is unlikely to be exceeded, the assumption of log normal distribution appears preferable to that of a normal distribution.

Acknowledgement

The authors are grateful to Dr. Lloyd Setter for stimulating discussions, careful scutiny of the data analysis, and a number of useful suggestions.

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Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of shortlived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionucides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by FRC Protective Action Guides (*4*) and the International Commission on Radiological Protection (*5, 6*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to assess man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in Milk, HASL	July–December 1965	June 1966
United Kingdom Milk	1962–1965	June 1966

1. Pasteurized Milk Network
March 1966

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN), was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling of major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the first quarter and March 1966 [a]

Sampling location		Calcium (g/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		First quarter 1966	March 1966	First quarter 1966	March 1966	First quarter 1966	March 1966
Ala:	Montgomery	1.17	1.11	12	13	25	20
Alaska:	Palmer	1.24	1.22	14	14	40	35
Ariz:	Phoenix	1.23	1.20	4	4	15	10
Ark:	Little Rock	1.17	1.14	26	30	40	35
Calif:	Sacramento	1.26	1.22	6	6	15	20
	San Francisco	1.24	1.24	7	8	20	20
C. Z:	Cristobal	1.12	1.12	4	5	25	20
Colo:	Denver	1.25	1.20	11	10	25	30
Conn:	Hartford	1.14	1.15	11	11	40	40
Del:	Wilmington	1.18	1.16	13	13	40	40
D. C:	Washington	1.15	1.14	12	12	30	25
Fla:	Tampa	1.17	1.16	11	10	105	100
Ga:	Atlanta	1.15	1.15	19	21	40	45
Hawaii:	Honolulu	1.17	1.17	5	5	35	30
Idaho:	Idaho Falls	1.25	1.22	13	14	40	45
Ill:	Chicago	1.12	1.11	11	11	35	40
Ind:	Indianapolis	1.18	1.16	12	11	30	30
Iowa:	Des Moines	1.24	1.23	14	13	30	40
Kans:	Wichita	1.26	1.21	13	13	20	20
Ky:	Louisville	1.16	1.14	16	18	25	20
La:	New Orleans	1.21	1.19	29	30	40	40
Maine:	Portland	1.15	1.14	15	16	65	70
Md:	Baltimore	1.15	1.15	13	13	30	30
Mass:	Boston	1.16	1.16	14	13	60	60
Mich:	Detroit	1.14	1.15	11	12	35	35
	Grand Rapids	1.19	1.17	14	14	45	45
Minn:	Minneapolis	1.24	1.23	20	21	40	35
Miss:	Jackson	1.24	1.21	23	26	25	25
Mo:	Kansas City	1.22	1.19	15	15	20	20
	St. Louis	1.21	1.23	15	15	30	35
Mont:	Helena	1.25	1.20	15	16	60	60
Nebr:	Omaha	1.24	1.23	15	15	25	30
Nev:	Las Vegas	1.23	1.19	7	5	20	20
N. H:	Manchester	1.17	1.16	18	18	75	75
N. J:	Trenton	1.15	1.13	12	11	40	35
N. Mex:	Albuquerque	1.24	1.20	6	6	15	15
N. Y:	Buffalo	1.12	1.10	10	12	40	40
	New York	1.11	1.11	13	13	45	45
	Syracuse	1.13	1.13	10	11	40	40
N. C:	Charlotte	1.17	1.12	20	21	30	30
N. Dak:	Minot	1.24	1.21	31	32	45	40
Ohio:	Cincinnati	1.16	1.16	12	11	25	30
	Cleveland	1.16	1.14	13	14	35	35
Okla:	Oklahoma City	1.15	1.14	13	14	25	25
Ore:	Portland	1.24	1.19	12	11	35	30
Pa:	Philadelphia	1.15	1.14	12	12	35	35
	Pittsburgh	1.17	1.16	17	17	45	45
P. R:	San Juan	1.12	1.10	8	9	25	20
R. I:	Providence	1.15	1.14	12	12	45	45
S. C:	Charleston	1.19	1.17	23	23	45	40
S. Dak:	Rapid City	1.15	1.21	19	21	45	45
Tenn:	Chattanooga	1.21	1.23	21	22	25	25
	Memphis	1.19	1.20	17	17	15	10
Tex:	Austin	1.15	1.13	6	6	15	10
	Dallas	1.18	1.16	14	14	20	20
Utah:	Salt Lake City	1.31	1.26	13	13	40	40
Vt:	Burlington	1.15	1.13	14	13	55	55
Va:	Norfolk	1.16	1.14	16	16	25	25
Wash:	Seattle	1.24	1.21	15	15	40	45
	Spokane	1.32	1.33	15	16	40	50
W. Va:	Charleston	1.15	1.16	14	15	25	20
Wis:	Milwaukee	1.20	1.19	11	11	40	40
Wyo:	Laramie	1.21	1.21	14	11	30	25
Network average		1.19	1.17	13.8	14.1	35	35

[a] Strontium-89 concentrations were all less than detectable level of 5 pCi/liter.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, March 1966 and October 1965–March 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965				1966		
	Mar	Oct	Nov	Dec	Jan	Feb	Mar
Under 10	5	8	9	9	10	9	9
10–19	29	46	43	43	46	46	44
20–29	21	7	9	11	6	7	7
30–39	6	2	2	0	1	1	3
40–49	1	0	0	0	0	0	0
50–59	1	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, March 1966 and October 1965–March 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965				1966		
	Mar	Oct	Nov	Dec	Jan	Feb	Mar
Under 50	9	54	57	51	57	56	56
50–99	36	8	5	11	5	6	6
100–149	16	0	1	1	1	1	1
150–199	2	1	0	0	0	0	0

The monthly averages for March 1966 and the first quarter averages for 1966 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values are below minimum detectable concentrations (*1*), averages are calculated using one-half the minimum detectable value.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for March 1965 and October 1965 through March 1966. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2. During March 1966, the monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

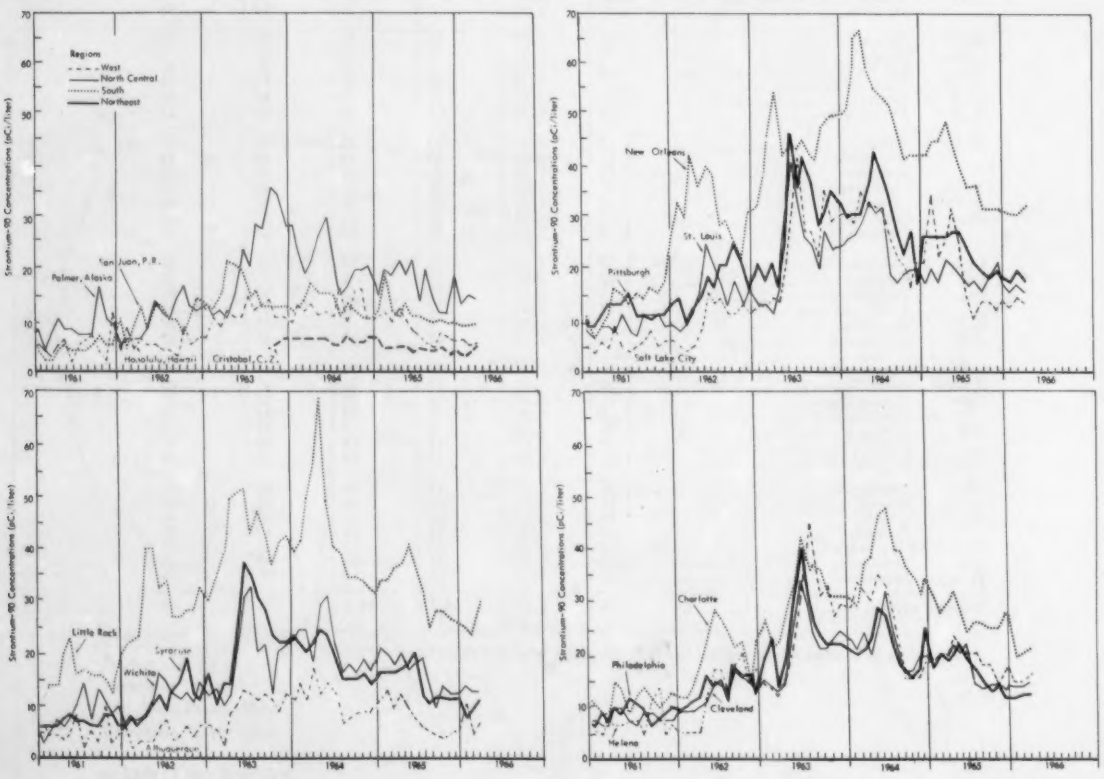

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961—March 1966

2. Canadian Milk Network March 1966[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, stable calcium, and stable potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The March 1966 monthly averages for strontium–90, cesium–137, stable calcium, and stable potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels during the period covered by this report.

[1] Prepared from April 1966 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 4. Stable elements and radionuclides in Canadian whole milk, March 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.12	1.4	20.7	71
Edmonton	1.10	1.5	19.1	65
Ft. William	1.10	1.6	27.9	93
Fredericton	1.12	1.6	29.3	76
Halifax	1.13	1.6	25.5	69
Montreal	1.08	1.6	17.7	50
Ottawa	1.15	1.4	14.1	40
Quebec	1.09	1.6	28.0	89
Regina	1.12	1.5	17.6	39
St. John's, Nfld.	1.08	1.6	23.3	88
Saskatoon	1.14	1.6	21.6	38
Sault Ste. Marie	1.11	1.6	26.8	72
Toronto	1.15	1.7	10.6	29
Vancouver	1.16	1.6	22.0	80
Windsor	1.12	1.6	11.3	33
Winnipeg	1.09	1.6	20.9	60
Average	1.12	1.6	21.0	62

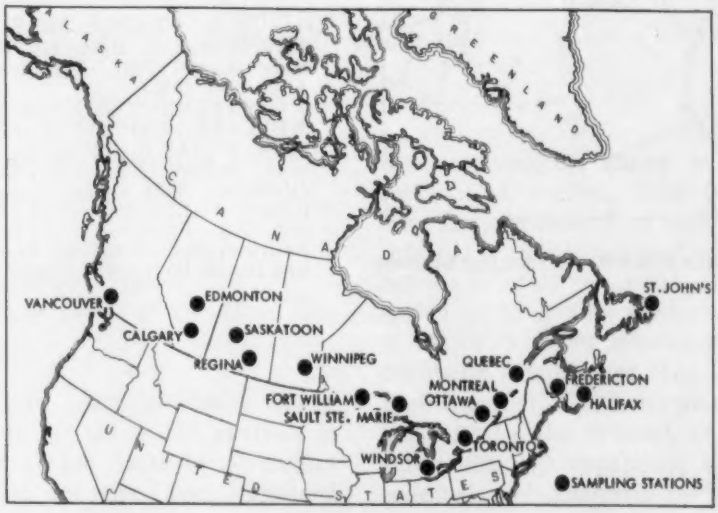

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program March 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Information on the sampling and analytical procedures employed appeared in the December 1965 issue of *Radiological Health Data* (*3*).

Figure 4. Pan American Milk Network sampling locations

Table 5 presents stable calcium and potassium, strontium–90, strontium–89 and cesium–137 monthly average concentrations for March 1966. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter for the period covered by this report.

Correction

There was an error in reporting the data for Caracas, Venezuela, in the June *Radiological Health Data and Reports;* the corrected values for February 1966 have been added to table 5.

Table 5. PAHO stable element and radionuclide concentrations in milk, March 1966

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.12	1.4	<5	5	20
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.25	1.4	<5	14	360
Puerto Rico:					
San Juan	1.10	1.4	<5	9	20
Venezuela:					
Caracas					
(Feb 1966) *	1.10	1.38	<5	4	20
(Mar 1966)	NS	NS	NS	NS	NS

NS, no sample collected.
* Corrected data for February 1966.

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STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States now have comprehensive environmental surveillance programs supported by functional radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein, while not inclusive, are representative of current surveillance activities directed toward the use of milk as an indication of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

Milk network	Period reported	Last presented
California	October–December 1965	June 1966
Colorado	October–December 1964	April 1965
Connecticut	October–December 1965	May 1966
Indiana	October–December 1965	May 1966
Michigan	October–December 1965	May 1966
Minnesota	July–December 1965	May 1966
New York	July–December 1965	May 1966
Oregon	October–December 1965	June 1966
Pennsylvania	October–December 1965	May 1966
Washington	October–December 1965	June 1966

1. Florida Milk Network January–March 1966

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, and cesium–137. Raw milk samples are received from the six areas shown in figure 1. Monthly samples are taken from randomly selected farms in the areas represented. A regional State Board of Health laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are now collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are charac-

terized by differences in dairying practices related to the gradual transition from small farms in the West Florida region, where locally grown feeds are used, to larger farms in the Southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter, *et al.* (*1*). Iodine–131 and cesium–137 are determined by gamma scintillation spectrometry (*2*).

Radionuclide concentration levels for January through March 1966 are presented in tables 1 and 2. During this period, iodine–131 concentrations remained below the minimum detectable level of 10 pCi/liter. Strontium–89 analyses have been discontinued due to extremely low levels during 1965.

Figure 1. Florida milk sampling areas

Table 1. Strontium-90 in Florida raw milk January–March 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay Area	Southeast Florida	Average
January—February	*25.9	*25.7	*12.6	NA	*12.3	*10.0	*17.3
March	28.5	24.2	11.9	NA	10.9	10.4	17.1
Average	27.2	24.9	12.2		11.6	10.2	17.2

* Composite for January and February.
NA, no analysis due to insufficient sample volume.

Table 2. Cesium-137 in Florida raw milk January–March 1966

Month	Concentration, pCi/liter						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay Area	Southeast Florida	Average
January	33	54	120	NA	104	134	89.0
February	37	71	107	NA	142	119	95.2
March	32	57	117	NA	122	116	88.8
Average	34.0	60.7	114.7		122.7	123.0	91.0

NA, no analysis due to insufficient sample volume.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1964	November 1965
January–June 1965	January 1966
July–December 1965	April 1966

2. Oklahoma Milk Network January–March 1966

Oklahoma State Department of Health[1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in milk produced in the State.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 2. Of the ten milksheds in the State, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine–131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 2, it is considered satisfactory for surveillance purposes.

At the present time, samples are collected each Monday morning and the analyses are completed by Wednesday afternoon. However, if iodine–131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about four hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The ion exchange method of analysis used is similar to that recently published by the Public Health Service (*3*), but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory. Details of the procedure used were presented earlier (*4*).

Iodine–131 concentrations in Oklahoma milk for the period of January through March 1966 were below the detectable level of 0.9 pCi/liter.

[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert L. Craig, assistant engineer.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
March–July 1965	October 1965
August–December 1965	April 1966

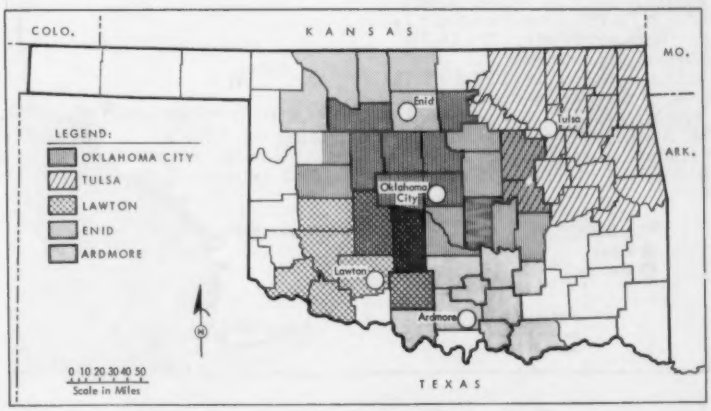

Figure 2. Oklahoma milkshed sampling areas

3. Texas Milk Network January–March 1966

Texas State Department of Health[2]

The Texas State Department of Health initiated a Statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "stand-by" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "stand-by" station locations, shown in figure 3, were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–89 and strontium–90 by chemical separation technique employing ion exchange columns (*5*).

Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry. Details of the analytical procedures were presented earlier (*6*).

Table 3 presents the January through March 1966 radionuclide concentrations in Texas milk. During this time, strontium–89, iodine–131, and barium 140 concentrations were below detectable levels. Strontium–90 and cesium–137 concentrations are shown graphically in figure 4 to indicate general trends.

[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

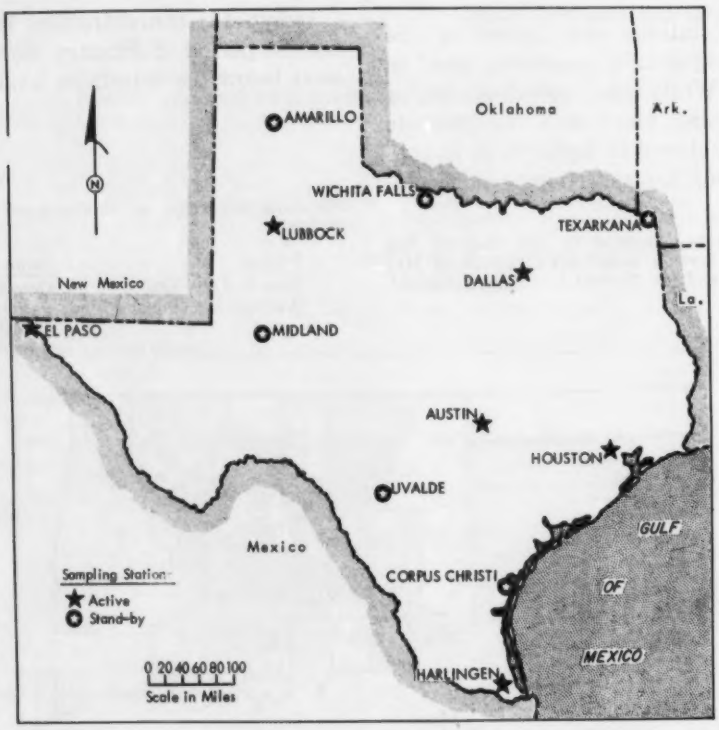

Figure 3. Texas milk sampling stations

Table 3. Radionuclide concentrations in Texas milk network, January–March 1966

Sampling location	Potassium-40, pCi/liter			Strontium-90, pCi/liter			Cesium-137, pCi/liter		
	January	February	March	January	February	March	January	February	March
Austin	1,280	NS	1,270	10	NS	5	30	NS	5
Dallas	1,350	NS	NS	11	NS	NS	20	NS	NS
El Paso	1,280	1,120	1,290	8	9	5	10	10	5
Harlingen	1,290	1,330	1,230	10	5	8	10	15	20
Houston	1,330	1,260	1,310	14	12	14	30	30	35
Lubbock	1,310	1,190	1,320	13	10	7	5	20	20
Average	1,307	1,250	1,284	11	9	8	17.5	18.8	17.0

NS, no sample collected

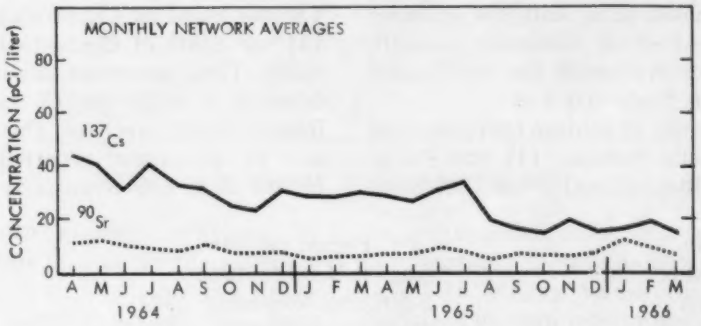

Figure 4. Radionuclide concentrations in Texas milk April 1964—March 1966

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Annual summary 1964	June 1965
January–March 1965	October 1965
April–December 1965	April 1966

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium–90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH. Florida milk network, July–December 1964. Rad Health Data 6:611–612 (November 1965).

(*3*) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine–131 from milk. Public Health Rep:453–456 (May 1965).

(*4*) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma milk network, March–July 1965. Rad Health Data 6:540–541 (October 1965).

(*5*) PORTER, C., and B. KAHN. Improved determina- of strontium–90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

(*6*) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January–March 1965. Rad Health Data 6:541–542 (October 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. The most recent coverage of programs reported in *Radiological Health Data and Reports* is listed below:

Program	Period reported	Last presented
Tri-City Diet, HASL	August-October 1965	June 1966
Teenage Diet, FDA	February–November 1964	July 1965
California Diet	May–August 1965	June 1966
Connecticut Standard Diet	January–June 1965	February 1966

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1. Radionuclides in Institutional Diet Samples October–December and Annual Summary 1965

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities distributed as shown in figure 1. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations. Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced to 21 as of July 1965.

Previous results showed that the amount of food consumed by teenage girls is comparable to that consumed by children 9 to 12 years of age, while teenage boys consume 20 percent more (*1, 2*). Consequently, dietary intake for teenage boys and/or girls can be estimated from the levels consumed for children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars,

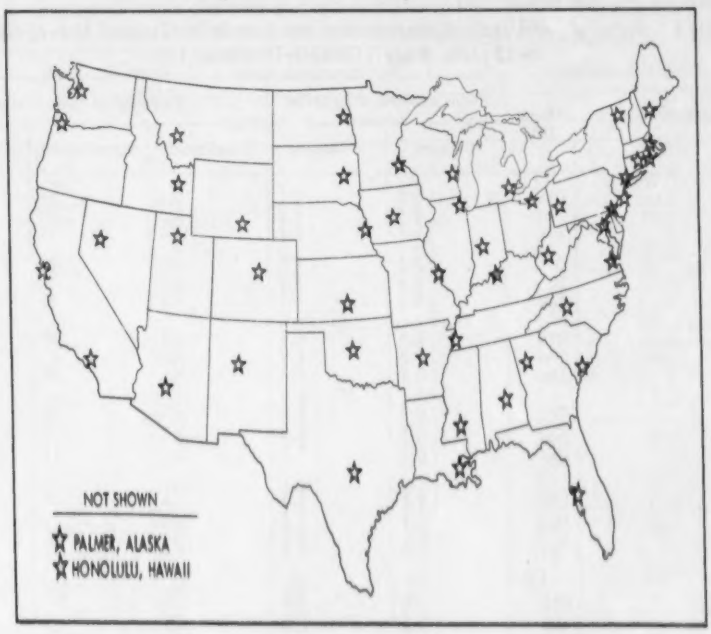

Figure 1. Institutional diet sampling locations

or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts. A detailed description of sampling and analytical procedures is presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from October through December 1965, for children 9 to 12 years of age. The twenty-one stations reported consist of at least two stations in each of nine geographic areas of the country and one station each in Hawaii and Alaska.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine–131 and barium–140 were interpreted as zero and "less than" 5 pCi/kg of strontium–89 as 2.5 pCi/kg.

The average food consumption rate during this period was 1.80 kg/day and was comparable with the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

While strontium–89 dietary intake remained below detectable levels, the strontium–90 dietary intake during this period remained fairly constant at approximately 23 pCi/day. The strontium–90 intakes fall within Range II as defined by the Federal Radiation Council (*5*), indicating that quantitative surveillance and routine control are recommended.

Cesium–137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*4*). During this period, both barium–140 and iodine–131 concentrations were below detectable levels.

Annual averages

Annual average radionuclide concentrations in 1965 institutional total diet samples are given in table 3. The corresponding annual average intakes are presented in table 4. During 1965 the annual average daily intake varied from 1.28 to 2.73 kg/day, with a mean of 1.89 kg/day. This value is in agreement with the 1961 through 1964 average (*4*). During this same period calcium intakes varied from 0.6

Table 1. Stable element and radionuclide concentrations in institutional diets of children (9–12 years of age), October–December 1965

Location of institution	Month 1965	Stable elements, g/kg of diet		Radionuclide concentrations, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	Oct	0.7	1.4	<5	31	55	0.3
	Nov	0.6	1.6	<5	20	55	0.6
	Dec	0.7	1.2	<5	21	70	0.4
Ariz: Phoenix	Oct	0.3	1.0	<5	13	40	0.3
	Nov	0.4	1.2	<5	8	35	0.1
	Dec	0.5	1.1	<5	14	25	0.3
Ark: Little Rock	Oct	0.6	1.3	<5	20	25	NA
	Nov	0.8	1.3	<5	12	25	NA
	Dec	0.7	1.3	<5	20	25	NA
Calif: Los Angeles	Oct	0.7	1.5	<5	4	35	0.3
	Nov	0.7	1.6	<5	6	15	0.4
	Dec	0.9	1.5	<5	11	35	0.4
Colo: Denver	Oct	0.6	1.3	<5	8	45	0.3
	Nov	0.7	1.5	<5	11	40	0.6
	Dec	0.9	1.5	<5	16	25	0.7
Del: Wilmington	Oct	NS	NS	NS	NS	NS	NS
	Nov	0.8	1.8	<5	10	25	0.9
	Dec	0.8	1.6	<5	11	40	0.1
Fla: Tampa	Oct	0.7	1.8	<5	12	90	NA
	Nov	0.6	1.7	<5	12	90	NA
	Dec	0.6	1.6	<5	11	60	NA
Hawaii: Honolulu	Oct	0.4	1.3	<5	<1	35	0.4
	Nov	0.5	1.5	<5	5	40	0.4
	Dec	0.5	1.3	<5	6	25	0.4
Idaho: Idaho Falls	Oct	1.4	1.6	<5	17	40	0.9
	Nov	1.0	1.6	<5	14	45	0.7
	Dec	1.4	1.6	<5	10	30	0.7
Ill: Chicago	Oct	0.7	1.4	<5	15	50	0.7
	Nov	0.6	1.4	<5	9	40	0.7
	Dec	0.7	1.6	<5	8	45	0.7
Ky: Louisville	Oct	0.6	1.7	<5	14	30	NA
	Nov	0.7	1.7	<5	15	30	NA
	Dec	0.9	1.8	<5	15	25	NA
La: New Orleans	Oct	0.8	1.3	<5	14	35	NA
	Nov	0.8	1.5	<5	19	45	NA
	Dec	0.7	1.6	<5	16	40	NA
Mass: Boston	Oct	0.5	1.5	<5	9	30	0.5
	Nov	0.7	1.1	<5	10	35	0.5
	Dec	0.6	1.4	<5	7	40	1.0
Mo: St. Louis	Oct	0.8	1.5	<5	12	30	0.8
	Nov	0.8	1.8	<5	10	35	0.9
	Dec	0.8	1.6	<5	11	30	0.5
Ohio: Cleveland	Oct	0.6	1.7	<5	6	25	0.5
	Nov	0.6	1.8	<5	6	35	0.7
	Dec	0.8	1.9	<5	12	60	0.9
Pa: Pittsburgh	Oct	0.6	1.3	<5	10	40	0.8
	Nov	0.6	1.4	<5	15	30	0.9
	Dec	0.6	1.2	<5	13	35	0.7
S. C: Charleston	Oct	0.7	1.8	<5	18	40	NA
	Nov	0.7	1.4	<5	16	40	NA
	Dec	0.8	1.7	<5	21	40	NA
S. Dak: Sioux Falls	Oct	0.7	1.3	<5	16	75	0.6
	Nov	0.7	1.4	<5	15	70	0.8
	Dec	0.6	1.7	<5	19	85	0.7
Tex: Austin	Oct	0.6	1.3	<5	6	15	NA
	Nov	0.6	1.4	<5	8	20	NA
	Dec	0.5	1.4	<5	8	25	NA
Vt: Burlington	Oct	0.6	1.4	<5	11	40	0.6
	Nov	0.6	1.6	<5	10	40	0.7
	Dec	1.0	1.8	<5	14	40	1.0
Wash: Seattle	Oct	0.5	1.3	<5	26	55	0.6
	Nov	0.6	1.4	<5	12	50	0.5
	Dec	1.3	1.8	<5	15	45	0.8
Institutional average	Oct	0.6	1.4	<5	13	40	0.5
	Nov	0.7	1.5	<5	12	40	0.6
	Dec	0.8	1.5	<5	13	40	0.6

NA, no analysis NS, no sample

Table 2. Intakes of stable elements and radionuclides in institutional total diet for children (9–12 years of age), October–December 1965

Location of institution	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	Oct	1.51	1.1	2.1	5	47	85	0.5
	Nov	1.48	0.9	2.4	5	30	80	0.9
	Dec	1.88	1.3	2.3	5	39	130	0.8
Ariz: Phoenix	Oct	1.77	0.5	1.8	5	23	70	0.5
	Nov	1.37	0.5	1.6	5	11	50	0.1
	Dec	2.00	1.0	2.2	5	28	50	0.6
Ark: Little Rock	Oct	1.16	0.7	1.5	5	23	30	NA
	Nov	1.78	1.4	2.3	5	21	45	NA
	Dec	1.78	1.2	2.3	5	36	45	NA
Calif: Los Angeles	Oct	[a] 1.80	1.3	2.7	5	7	65	0.5
	Nov	[a] 2.03	1.4	3.2	5	12	30	0.8
	Dec	[a] 2.40	2.2	3.6	5	26	85	1.0
Colo: Denver	Oct	2.41	1.4	3.1	5	19	110	0.7
	Nov	2.09	1.5	3.1	5	23	85	1.3
	Dec	2.26	2.0	3.4	5	36	55	1.6
Del: Wilmington	Oct	NS	NS	NS	NS	NS	NS	NS
	Nov	1.98	1.6	3.6	5	20	50	1.8
	Dec	1.81	1.4	2.9	5	20	70	0.2
Fla: Tampa	Oct	2.18	1.5	3.9	5	26	195	NA
	Nov	2.01	1.2	3.4	5	24	180	NA
	Dec	1.80	1.1	2.9	5	20	110	NA
Hawaii: Honolulu	Oct	[a] 1.78	0.7	2.3	5	1	60	0.7
	Nov	1.75	0.9	2.6	5	9	70	0.7
	Dec	1.87	0.9	2.4	5	11	45	0.7
Idaho: Idaho Falls	Oct	[a] 1.80	2.5	2.9	5	31	70	1.6
	Nov	[a] 1.92	1.9	3.1	5	27	85	1.3
	Dec	[a] 1.99	2.8	3 2	5	20	60	1.4
Ill: Chicago	Oct	1.14	0.8	1.6	5	17	55	0.8
	Nov	1.53	0.9	2.1	5	14	60	1.1
	Dec	1.26	0.9	2.0	5	10	55	0.9
Ky: Louisville	Oct	1.28	0.8	2.2	5	18	40	NA
	Nov	1.59	1.1	2.7	5	24	50	NA
	Dec	1.50	1.4	2.7	5	22	40	NA
La: New Orleans	Oct	1.78	1.4	2.3	5	25	60	NA
	Nov	2.47	2.0	3.7	5	47	110	NA
	Dec	[b] 2.17	1.5	3.5	5	35	85	NA
Mass: Boston	Oct	2.68	1.3	4.0	5	24	80	1.3
	Nov	2.55	1.8	2.8	5	26	90	1.3
	Dec	2.25	1.4	3.2	5	16	90	2.2
Mo: St. Louis	Oct	2.28	1.8	3.4	5	27	70	1.8
	Nov	2.39	1.9	4.3	5	24	85	2.2
	Dec	2.38	1.9	3.8	5	26	70	1.2
Ohio: Cleveland	Oct	1.76	1.1	3.0	5	11	45	0.9
	Nov	1.49	0.9	2.7	5	9	50	1.0
	Dec	1.48	1.2	2.8	5	18	90	1.3
Pa: Pittsburgh	Oct	[a] 2.32	1.4	3.0	5	23	95	1.9
	Nov	[a] 2.36	1.4	3.3	5	35	70	2.1
	Dec	[a] 2.31	1.4	2.8	5	30	80	1.6
S. C: Charleston	Oct	1.73	1.2	3.1	5	31	70	NA
	Nov	1.52	1.1	2.1	5	24	60	NA
	Dec	1.86	1.5	3.2	5	39	75	NA
S. Dak: Sioux Falls	Oct	1.70	1.2	2.2	5	27	130	1.0
	Nov	1.89	1.3	2.6	5	28	130	1.5
	Dec	1.82	1.1	3.1	5	34	155	1.3
Tex: Austin	Oct	1.70	1.0	2.2	5	10	25	NA
	Nov	1.63	1.0	2.3	5	13	35	NA
	Dec	1.63	0.8	2.3	5	13	40	NA
Vt: Burlington	Oct	1.77	1.1	2.5	5	19	70	1.1
	Nov	1.43	0.9	2.3	5	14	55	1.0
	Dec	1.23	1.2	2.2	5	17	50	1.2
Wash: Seattle	Oct	[a] 1.67	0.8	2.2	5	43	90	1.0
	Nov	[a] 1.53	0.9	2.1	5	18	75	0.8
	Dec	[a] 1.63	2.1	2.9	5	24	75	1.3
Institutional average	Oct	1.79	1.1	2.6	5	23	75	1.0
	Nov	1.82	1.2	2.7	5	21	75	1.2
	Dec	1.80	1.3	2.7	5	24	75	1.1

[a] Data for these months were not used in the average because food samples were collected from two or more children over 12 years of age.
[b] Data for these months were not used in the average because food samples were collected from children whose ages were unknown.
NS, no sample collected NA, no analysis

Table 3. Annual average concentrations of stable elements and radionuclides in institutional daily diets of school children, 1965 [a]

Location of institution		Stable elements, g/kg of diets		Radionuclide concentration, pCi/kg of diet			
		Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery [b]	0.6	1.2	<5	12	40	[c] NA
Alaska:	Palmer	0.6	1.3	<5	18	80	0.4
Ariz:	Phoenix [d]	0.6	1.3	<5	14	50	0.5
Ark:	Little Rock	0.7	1.3	<5	21	35	NA
Calif:	Los Angeles	0.7	1.6	<5	8	30	0.6
	San Francisco [c]	0.6	1.6	<5	13	35	0.5
Colo:	Denver	0.7	1.4	<5	14	45	0.6
Conn:	Hartford [b]	0.7	1.6	<5	12	75	0.6
Del:	Wilmington	0.8	1.7	<5	12	50	0.7
Fla:	Tampa	0.7	1.7	<5	12	100	NA
Ga:	Atlanta [b]	0.6	1.6	<5	18	60	NA
Hawaii:	Honolulu	0.5	1.2	<5	11	35	0.6
Idaho:	Idaho Falls	0.9	1.6	<5	21	75	0.6
Ill:	Chicago	0.7	1.5	<5	11	60	0.6
Ind:	Indianapolis [b]	0.8	1.5	5	12	60	0.6
Iowa:	Des Moines [b]	0.6	1.6	<5	14	55	NA
Kans:	Witchita [b]	0.8	1.6	5	15	45	NA
Ky:	Louisville [d]	0.6	1.4	<5	16	35	NA
La:	New Orleans	0.7	1.5	<5	18	50	NA
Maine:	Portland [b]	0.8	1.4	<5	15	90	0.6
Md:	Baltimore [b]	0.6	1.4	<5	15	50	NA
Mass:	Boston (A) [b]	0.7	1.5	<5	14	85	0.6
	Boston (B) [d]	0.6	1.4	<5	9	45	0.6
Mich:	Detroit [b]	0.8	1.6	<5	11	70	0.7
Minn:	Minneapolis [b]	0.7	1.6	<5	30	65	0.7
Miss:	Columbia [b]	0.8	1.5	<5	22	70	NA
Mo:	St. Louis	0.7	1.6	<5	18	40	0.8
Mont:	Helena [b]	0.5	1.2	<5	14	55	0.6
Nebr:	Omaha [b]	0.8	1.5	<5	20	55	0.8
Nev:	Carson City [b]	0.8	1.5	<5	18	40	0.8
N.J:	Trenton [b]	0.7	1.4	<5	12	60	1.0
N. Mex:	Albuquerque [b]	0.8	1.6	<5	12	30	0.7
N.Y:	New York [b]	0.8	1.6	<5	14	75	0.9
N.C:	Charlotte [b]	0.6	1.1	<5	15	40	NA
N. Dak:	Fargo [b]	0.7	1.6	<5	14	70	0.6
Ohio:	Cleveland	0.7	1.7	<5	10	55	0.6
Okla:	Oklahoma City [b]	0.6	1.5	<5	12	35	NA
Ore:	Portland [b]	0.6	1.6	<5	15	50	0.6
Pa:	Pittsburgh	0.6	1.4	<5	13	50	0.7
R.I:	Providence [b d]	0.8	1.5	<5	12	75	0.5
S.C:	Charleston	0.7	1.4	<5	18	55	NA
S. Dak:	Sioux Falls	0.8	1.6	<5	16	75	0.7
Tenn:	Memphis [b]	0.6	1.4	<5	16	40	NA
Tex:	Austin	0.5	1.2	<5	8	25	NA
Utah:	Salt Lake City [b]	0.6	1.6	<5	14	65	0.5
Vt:	Burlington	0.8	1.6	<5	14	65	0.6
Va:	Norfolk [b]	0.5	1.2	<5	16	45	NA
Wash:	Seattle	0.7	1.6	<5	21	70	0.5
W. Va:	Charleston [b]	0.8	1.6	<5	19	55	NA
Wis:	Milwaukee [b]	0.6	1.6	<5	10	70	0.7
Wyo:	Laramie [b]	0.7	1.6	<5	15	60	1.0
Institutional average		0.7	1.5	<5	15	55	0.6

[a] Iodine-131 and barium-140 concentrations are not presented in this table; concentrations were reported as not detectable (<10) each month at each institution.

[b] Strontium-90 and cesium-137 concentrations are probably maximum values. Sample collection at these stations was limited to the first half of the year. In general, peak levels for these radionuclides were observed during the first 7 months of 1965.

[c] NA, no analysis

[d] Station entered the network in January 1965.

[e] Values represent data for 3 months.

to 2.0 g/day, with a mean of 1.3 g/day. Potassium annual average intakes ranged from 1.6 to 4.3 g/day, with a mean of 2.8 g/day.

Annual average daily intakes of strontium–89 were less than 10 pCi/day. During 1965, annual average strontium–90 intakes ranged from 13 to 64 pCi/day with a mean of 28 pCi/day. The latter fall within FRC Range II (*5*), indicating that quantitative surveillance and routine control are the recommended course of action.

Cesium–137 annual average intakes ranged from 40 to 215 pCi/day with a mean of 105 pCi/day. At the same time, radium–226 intakes averaged 1.2 pCi/day.

During 1965, both iodine–131 and barium–140 concentrations were below detectable levels.

Table 4. Annual average intake of selected elements and radionuclides in institutional daily diets of school children, 1965 [a]

Location of institution		Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery [b]	2.30	1.3	2.9	5	28	90	[c] NA
Alaska:	Palmer	1.53	1.0	2.0	5	29	125	0.6
Ariz:	Phoenix [d]	1.60	1.0	2.1	5	22	75	0.7
Ark:	Little Rock	1.77	1.2	2.3	5	37	65	NA
Calif:	Los Angeles	1.75	1.3	2.7	5	14	55	1.0
	San Francisco [e]	1.70	1.1	2.7	5	21	60	0.9
Colo:	Denver	2.24	1.5	3.2	5	30	100	1.3
Conn:	Hartford [b]	1.78	1.3	3.0	5	20	135	1.0
Del:	Wilmington	1.89	1.5	3.2	5	23	95	1.3
Fla:	Tampa	2.11	1.5	3.5	5	26	215	NA
Ga:	Atlanta [b]	1.72	1.0	2.8	5	31	110	NA
Hawaii:	Honolulu	1.80	0.9	2.1	5	19	65	1.1
Idaho:	Idaho Falls	1.93	1.7	3.0	10	40	140	1.2
Ill:	Chicago	1.46	1.1	2.2	5	16	85	0.8
Ind:	Indianapolis [b]	1.61	1.3	2.4	10	20	95	0.9
Iowa:	Des Moines [b]	2.73	1.8	4.3	5	39	155	NA
Kans:	Wichita [b]	1.99	1.6	3.2	10	30	90	NA
Ky:	Louisville [d]	1.75	1.2	2.5	5	28	60	NA
La:	New Orleans	2.33	1.6	3.4	5	42	120	NA
Maine:	Portland [b]	2.31	1.8	3.4	5	35	205	1.4
Md:	Baltimore [b]	1.81	1.1	2.4	5	28	90	NA
Mass:	Boston (A) [b]	2.23	1.5	3.3	5	30	190	1.2
	Boston (B) [d]	2.38	1.4	3.3	5	22	100	1.4
Mich:	Detroit [b]	1.88	1.5	2.9	5	20	130	1.4
Minn:	Minneapolis [b]	2.08	1.5	3.4	5	64	140	1.4
Miss:	Columbia [b]	2.30	1.9	3.4	10	49	160	NA
Mo:	St. Louis	2.30	1.7	3.6	5	39	85	1.8
Mont:	Helena [b]	1.35	0.6	1.7	5	20	80	0.8
Nebr:	Omaha [b]	1.79	1.4	2.7	5	36	100	1.4
Nev:	Carson City [b]	1.45	1.2	2.2	5	28	60	1.1
N.J:	Trenton [b]	2.25	1.5	3.2	5	27	135	2.2
N. Mex:	Albuquerque [b]	2.04	1.6	3.2	5	24	65	1.4
N.Y:	New York [b]	2.30	1.7	3.6	5	33	170	2.1
N.C:	Charlotte [b]	1.44	0.9	1.6	5	22	60	NA
N. Dak:	Fargo [b]	1.37	1.0	2.2	5	18	100	0.8
Ohio:	Cleveland	1.56	1.0	2.7	5	16	85	1.0
Okla:	Oklahoma City [b]	1.71	1.1	2.6	5	21	60	NA
Ore:	Portland [b]	2.04	1.1	3.1	5	29	105	1.2
Pa:	Pittsburgh	2.40	1.4	3.4	5	32	125	1.7
R.I:	Providence [b d]	2.60	2.0	4.0	5	31	200	1.3
S.C:	Charleston	1.72	1.2	2.5	5	32	95	NA
S. Dak:	Sioux Falls	1.78	1.3	2.9	10	29	130	1.2
Tenn:	Memphis [b]	1.58	1.0	2.3	5	26	60	NA
Tex:	Austin	1.74	0.8	2.1	5	13	40	NA
Utah:	Salt Lake City [b]	1.28	0.8	2.0	5	18	85	0.7
Vt:	Burlington	1.41	1.1	2.3	5	19	95	0.9
Va:	Norfolk [b]	2.30	1.2	2.8	5	37	100	NA
Wash:	Seattle	1.74	1.2	2.7	5	37	120	0.9
W. Va:	Charleston [b]	1.69	1.2	2.8	5	32	95	NA
Wis:	Milwaukee [b]	2.08	1.3	3.3	5	22	140	1.6
Wyo:	Laramie [b]	1.58	1.1	2.6	5	24	95	1.5
Institutional average		1.89	1.3	2.8	5	28	105	1.2

[a] Iodine-131 and barium-140 intakes are not presented in this table; values were zero for each month at each institution.
[b] Strontium-90 and cesium-137 intakes are probably maximum values. Sample collection at these stations was limited to the first half of the year. In general, peak levels for these radionuclides were observed during the first 7 months of 1965.
[c] NA, no analysis
[d] Station entered the network in January 1965.
[e] Values represent data for 3 months.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1964	October 1964
April–June 1964	January 1965
July–September 1964	April 1965
October–December 1964	July 1965
Annual averages 1964	July 1965
January–March 1965	October 1965
April–June 1965	February 1966
July–September 1965	May 1966

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(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Rad Health Data 6: 548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, April–June 1965. Rad Health Data and Rep 7:92–98 (February 1966).

(*4*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Rad Health Data 6: 691–698 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guidance recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	May and July–November 1965	June 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
California Water Sampling Program	January–June 1965	March 1966
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JANUARY 1966

Basic Data Program, Federal Water Pollution Control Administration
Department of the Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater, or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Serv-

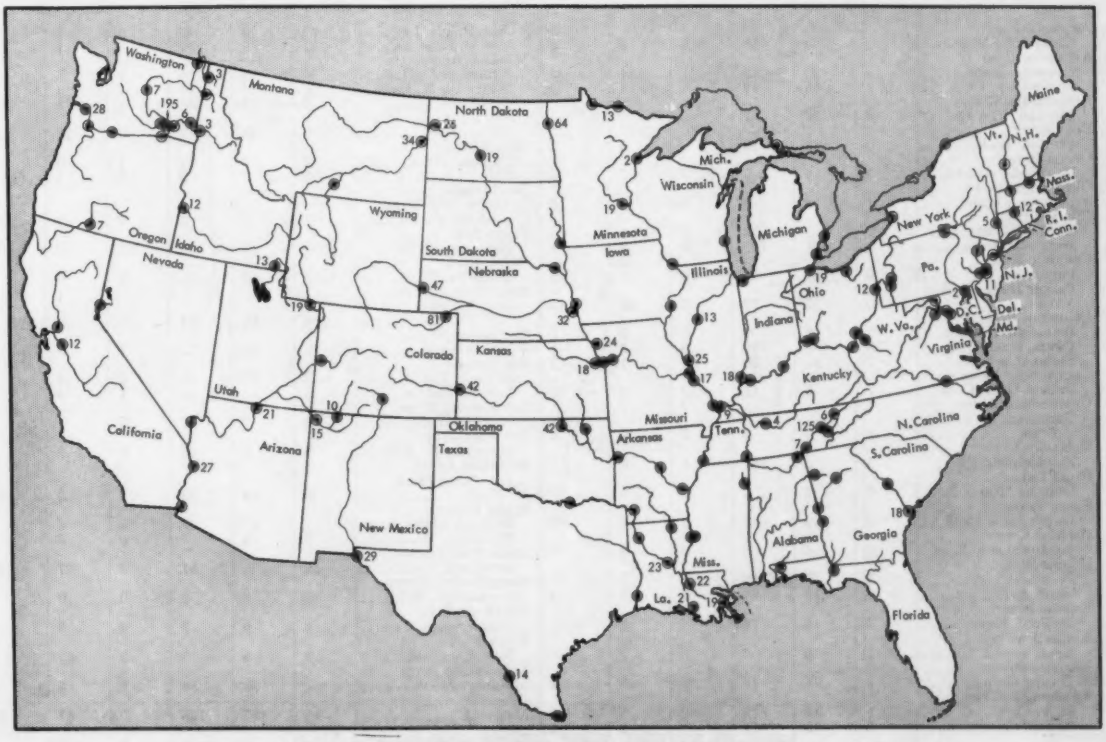

Figure 1. Sampling locations and associated total beta activity, pCi/liter in surface waters, January 1966

ice drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During December 1965 and January 1966 the following stations showed alpha values in excess of 15 pCi/liter in the dissolved solids:

Arkansas River: Coolidge, Kansas

North Platte River: Henry, Nebraska

South Platte River: Julesburg, Colorado

The station at Pasco, Washington, showed an increase in beta radioactivity in dissolved solids from below 150 pCi/liter in December to more than 150 pCi/liter for January 1966.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(2) Ibid., 1959 Edition.

(3) Ibid., 1960 Edition.

(4) Ibid., 1961 Edition.

(5) Ibid., 1962 Edition.

(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Table 1. Radioactivity in raw surface waters, January 1966

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	2	8	10	<1	2	2
Arkansas River:						
Coolidge, Kans.	5	37	42	1	24	25
Ponca City, Okla.	7	35	42	1	13	14
Atchafalaya River:						
Morgan City, La.	9	12	21	2	2	4
Bear River:						
Preston, Idaho	0	13	13	0	2	2
Chena River:						
Fairbanks, Alaska	<1	2	2	0	0	0
Clearwater River:						
Lewiston, Idaho	1	2	3	0	0	0
Clinch River:						
Clinton, Tenn.	1	5	6	0	0	0
Kingston, Tenn.*	4	121	125	0	1	1
Colorado River:						
Page, Ariz.	0	21	21	0	5	5
Parker Dam, Calif.-Ariz.	0	27	27	0	13	13
Columbia River:						
Wenatchee, Wash.	1	6	7	0	0	0
Pasco, Wash.*	28	167	195	0	1	1
Clatskanie, Ore.	7	21	28	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn.	7	5	12	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	1	3	4	0	0	0
Delaware River:						
Philadelphia, Pa.	5	6	11	1	0	1
Great Lakes:						
Duluth, Minn.	0	2	2	0	0	0
Green River:						
Dutch John, Utah	0	19	19	0	4	4
Hudson River:						
Poughkeepsie, N.Y.	1	4	5	0	0	0
Illinois River:						
Peoria, Ill.	3	10	13	0	1	1
Grafton, Ill.	6	19	25	2	2	4
Kansas River:						
De Soto, Kans.	3	15	18	1	4	5
Klamath River:						
Keno, Ore.	1	6	7	0	0	0
Maumee River:						
Toledo, Ohio	5	14	19	1	3	4
Mississippi River:						
St. Paul, Minn.	1	18	19	0	1	1
E. St. Louis, Ill.	5	12	17	1	1	2
New Roads, La.	12	10	22	5	1	6
New Orleans, La.	10	9	19	2	1	3
Missouri River:						
Williston, N. Dak.	4	22	26	1	5	6
Bismarck, N. Dak.	2	17	19	1	3	4
St. Joseph, Mo.	5	19	24	1	5	6
North Platte River:						
Henry, Nebr.	2	45	47	0	27	27
Ohio River:						
Toronto, Ohio	6	6	12	1	0	1
Cairo, Ill.	2	7	9	1	1	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	3	3	0	<1	<1
Platte River:						
Plattsmouth, Nebr.	4	28	32	<1	10	10
Rainy River:						
Baudette, Minn.	1	12	13	0	0	0
Red River, North:						
Grand Forks, N. Dak.	0	64	64	0	3	3
Red River, South:						
Alexandria, La.	9	14	23	1	0	1
Rio Grande:						
El Paso, Tex.	2	27	29	0	4	4
Laredo, Tex.	3	11	14	1	4	5
San Joaquin River:						
Vernalis, Calif.	5	7	12	2	1	3
San Juan River:						
Shiprock, N. Mex.	6	9	15	1	2	3
Savannah River:						
Port Wentworth, Ga.*	8	10	18	<1	0	<1
Snake River:						
Payette, Idaho	1	11	12	0	4	4
Wawawai, Wash.	0	6	6	0	2	2
South Platte River:						
Julesburg, Colo.	15	66	81	5	37	42
Susquehanna River:						
Conowingo, Md.	0	2	2	0	0	0
Tennessee River:						
Chattanooga, Tenn.	1	6	7	0	0	0
Wabash River:						
New Harmony, Ind.	9	9	18	3	<1	3
Yellowstone River:						
Sidney, Mont.	1	33	34	0	8	8
Maximum	28	167	195	5	37	42
Minimum	0	2	2	0	0	0

* Gross beta activities at these stations are not directly comparable to gross beta activity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES JULY–DECEMBER 1965[1]

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes through the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul; and monthly at Crookston, International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

[1] Data and information from "Survey of Environmental Radioactivity, July–December 1965," Pub No. C00–651–25. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minnesota 55440.

Figure 1. Minnesota surface water sampling locations

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250-ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta activity in Minnesota municipal water supplies from July through December 1965. The minimum reported level corresponding to an error of one standard deviation is 15 pCi/liter. In averaging, the value 7 pCi/liter is used for samples having less than the minimum detectable value.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 7 to 51 pCi/liter, which is well below the Public Health Service Drinking Water Standard of 1,000 pCi/liter in the known absence of alpha emitters and strontium–90 (*1*). Treated water in most cases contained less beta activity than the corresponding raw water.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 1. Total beta concentrations in Minnesota raw and treated water supplies, July–December 1965

Town and water source	Average concentrations, pCi/liter						
	Type of water	July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	35	NS	38	26	28	13
	Treated	33	NS	7	7	26	36
East Grand Forks, Red Lake River	Raw	27	12	24	24	34	31
	Treated	20	12	9	18	15	10
Eveleth, St. Mary's Lake	Raw	15	18	7	24	21	22
	Treated	17	17	16	23	19	18
Fairmont, Budd Lake	Raw	18	18	15	19	19	11
	Treated	7	9	7	9	7	11
Hallock, Two Rivers, South Fork	Raw	51	40	38	39	32	33
	Treated	15	17	13	14	7	11
International Falls, Rainy River	Raw	7	NS	NS	17	NS	7
	Treated	25	NS	NS	18	NS	12
Minneapolis tap water	Treated	12	11	7	18	9	14
St. Cloud, Mississippi River	Raw	7	NS	7	28	NS	18
	Treated	7	NS	18	14	NS	12
St. Paul, Vadnais Chain of Lakes	Raw	19	14	22	24	21	18
	Treated	11	7	15	19	10	10

NS, no samples collected.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
August 1959–April 1962	August 1962
April 1962–November 1962	April 1963
December 1962–June 1963	November 1963
July–December 1963	June 1964
January–June 1964	January 1965
July–December 1964	August 1965
January–June 1965	February 1966

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity arising through air intrusions such as weapons testing fallout. To date this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to those presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last presented
Mexican Air Monitoring Program	December 1965	April 1966
National Air Sampling Network	October–December and annual summary 1965	April 1966
HASL Fallout Network	January–June 1965	May 1966

1. Radiation Surveillance Network March 1966

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during March 1966. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on air samples. Traces of longer-lived fresh fission products were identified in most of these.

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, March 1966

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in RHD&R	Total depth (mm)	Total deposition (nCi/m²) *
		Air	Pptn	Maximum	Minimum	Average *			
Ala:	Montgomery	31	4	0.23	<0.10	<0.13	Feb 66	88	<18
Alaska	Adak	30	NS	0.24	<0.10	<0.11	Jun 66		
	Anchorage	21	1	<0.10	<0.10	<0.10	Mar 66	2	<1
	Attu Island	NS	NS				Jul 66		
	Fairbanks	9	2	<0.10	<0.10	<0.10	Apr 66	3	<1
	Juneau	21	15	<0.10	<0.10	<0.10	May 66	224	<45
	Kodiak	1	NS	0.12	0.12	0.12	May 66		
	Nome	NS	NS				Dec 65		
	Pt. Barrow	31	NS	<0.10	<0.10	<0.10	Nov 65		
	St. Paul Island	31	NS	0.11	<0.10	<0.10	Jan 66		
Ariz:	Phoenix	31	NS	0.30	<0.10	<0.14	May 66		
Ark:	Little Rock	20	1	0.20	<0.10	<0.12	Mar 66	7	<1
Calif:	Berkeley	23	2	0.46	<0.10	<0.16	May 66	14	<3
	Los Angeles	22	1	0.37	<0.10	<0.15	Dec 65	11	<2
C.Z:	Ancon	19	NS	<0.10	<0.10	<0.10	May 66		
Colo:	Denver	30	NS	0.25	<0.10	<0.14	May 66		
Conn:	Hartford	31	10	0.13	<0.10	<0.10	Apr 66	73	<15
Del:	Dover	22	NS	0.15	<0.10	<0.10	Feb 66		
D.C:	Washington	29	7	0.16	<0.10	<0.11	Nov 65	54	<11
Fla:	Jacksonville	31	6	0.17	<0.10	<0.12	Mar 66	88	<18
	Miami	31	5	0.24	<0.10	<0.14	Apr 66	95	<19
Ga:	Atlanta	31	5	0.20	<0.10	<0.12	Jan 66	138	<28
Guam:	Agana	31	NS	<0.10	<0.10	<0.10	Feb 66		
Hawaii:	Honolulu	31	1	0.13	<0.10	<0.10	Jul 66	6	<1
Idaho:	Boise	29	6	0.16	<0.10	<0.11	Jul 66	21	<4
Ill:	Springfield	27	3	0.17	<0.10	<0.11	Nov 65	29	<6
Ind:	Indianapolis	30	7	0.18	<0.10	<0.11	Jan 66	36	<7
Iowa:	Iowa City	31	4	0.15	<0.10	<0.11	May 66	54	<11
Kans:	Topeka	31	NS	0.16	<0.10	<0.11	Mar 66		
Ky:	Frankfort	30	4	0.22	<0.10	<0.13	Nov 65	30	<6
La:	New Orleans	31	6	0.20	<0.10	<0.12	Nov 65	83	<17
Maine:	Augusta	31	12	0.12	<0.10	<0.10	Dec 65	119	<24
	Presque Isle	23	NS	0.13	<0.10	<0.10	May 66		
Md:	Baltimore	22	5	0.19	<0.10	<0.12	Apr 66	28	<6
	Rockville	19	NS	0.15	<0.10	<0.11	Jul 66		
Mass:	Lawrence	31	8	0.24	<0.10	<0.12	Feb 66	52	<10
	Winchester	27	8	0.15	<0.10	<0.10	Jun 66	47	<10
Mich:	Lansing	31	5	0.22	<0.10	<0.12	Jul 66	31	<6
Minn:	Minneapolis	22	3	0.14	<0.10	<0.10	Feb 66	26	<5
Miss:	Jackson	28	2	0.16	<0.10	<0.11	Dec 65	15	<3
Mo:	Jefferson City	31	6	0.18	<0.10	<0.11	Jan 66	36	<7
Mont:	Helena	30	4	0.21	<0.10	<0.13	Jun 66	12	<2
Nebr:	Lincoln	21	1	0.13	<0.10	<0.10	Jan 66	72	<15
Nev:	Las Vegas	28	NS	0.27	<0.10	<0.15	Apr 66		
N.H:	Concord	22	NS	0.20	<0.10	<0.11	Nov 65		
N.J:	Trenton	31	3	0.17	<0.10	<0.11	Dec 65	12	<3
N. Mex	Sante Fe	26	3	0.20	<0.10	<0.12	Jun 66	9	<2
N.Y:	Albany	21	7	0.15	<0.10	<0.10	Jan 66	86	<17
	Buffalo	31	NS	0.13	<0.10	<0.10	May 66		
	New York	31	NS	0.13	<0.10	<0.10	Jun 66		
N.C:	Gastonia	29	4	0.21	<0.10	<0.13	May 66	72	<14
N. Dak	Bismarck	28	NS	0.13	<0.10	<0.10	Nov 65		
Ohio:	Cincinnati	20	NS	<0.10	<0.10	<0.10	Feb 66		
	Columbus	31	7	0.29	<0.10	<0.16	Dec 65	29	<6
	Painesville	29	11	0.17	<0.10	<0.12	Apr 66	73	<15
Okla:	Oklahoma City	30	1	0.13	<0.10	<0.10	Jul 66	16	<3
	Ponca City	29	NS	<0.10	<0.10	<0.10	Apr 66		
Ore:	Portland	31	18	0.35	<0.10	<0.15	Jan 66	100	<20
Pa:	Harrisburg	30	8	0.14	<0.10	<0.10	Jan 66	51	<10
P.R:	San Juan	27	7	0.20	<0.10	<0.11	Dec 65	114	<23
R.I:	Providence	27		0.15	<0.10	<0.10	Jul 66	52	<10
S.C:	Columbia	30	5	0.16	<0.10	<0.12	Jun 66	69	<14
S. Dak:	Pierre	29	1	0.17	<0.10	<0.11	May 66	10	3
Tenn:	Nashville	30	5	0.19	<0.10	<0.11	Jul 66	29	<6
Tex:	Austin	30	5	0.22	<0.10	<0.12	Feb 66	16	<3
	El Paso	30	2	0.23	<0.10	<0.13	Nov 65		
Utah:	Salt Lake City	31	7	0.30	<0.10	<0.13	Dec 65	25	<5
Vt:	Barre	30	9	0.18	<0.10	<0.11	Mar 66	55	<11
Va:	Richmond	29	5	0.29	<0.10	<0.11	Mar 66	50	<10
Wash:	Seattle	31	7	0.13	<0.10	<0.10	Mar 66	81	<16
	Spokane	30	6	0.22	<0.10	<0.12	Feb 66	35	<7
W. Va:	Charleston	31	6	0.17	<0.10	<0.11	Jun 66	40	<8
Wis:	Madison		7	0.15	<0.10	<0.10	Mar 66	56	<11
Wyo:	Cheyenne		NS	0.24	<0.10	<0.14	Apr 66		
Network summary		1,974	283	0.46	<0.10	<0.11		50	<10

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.
NS, no air or precipitation sample collected.

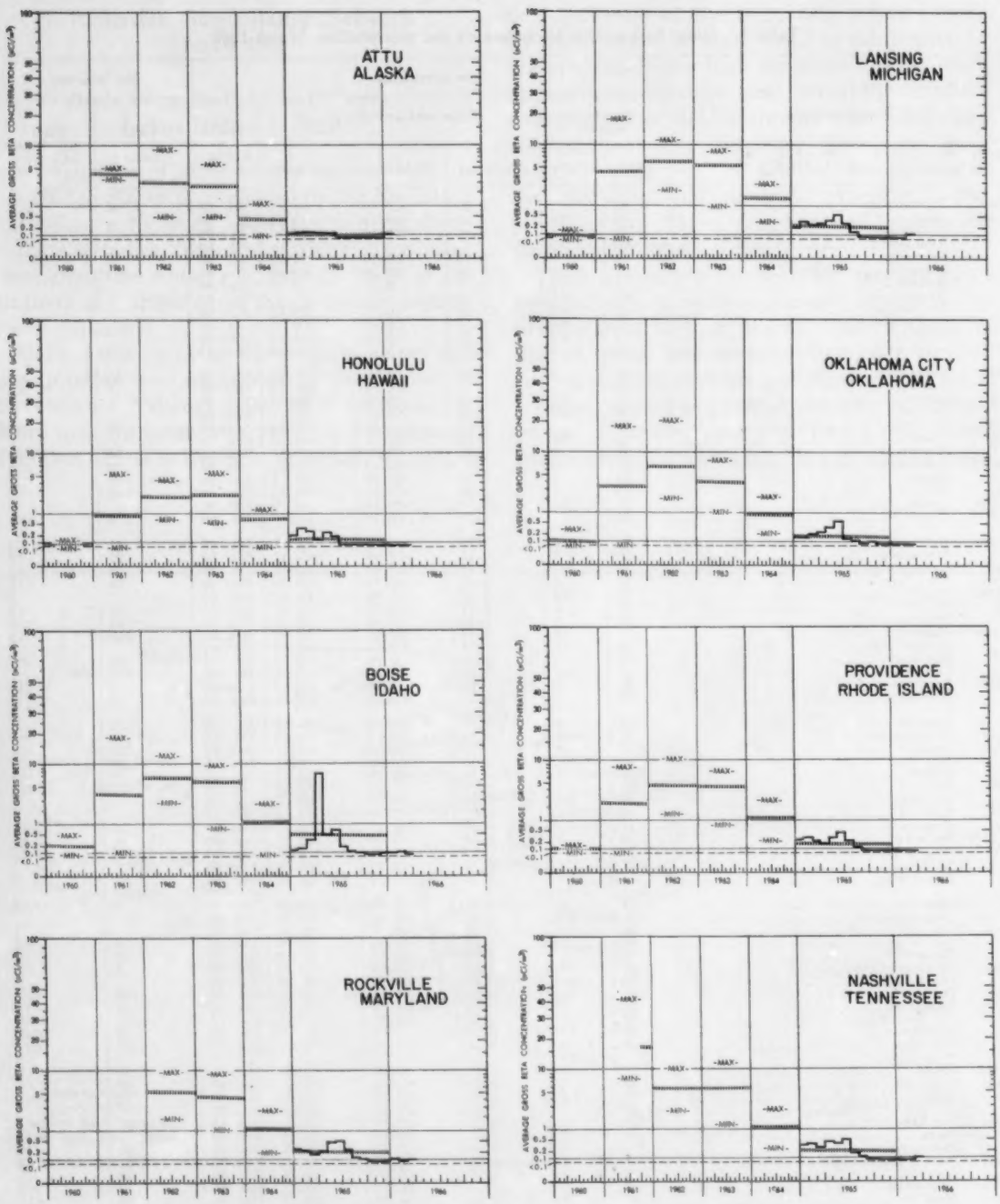

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1960—March 1966

2. Canadian Air and Precipitation Monitoring Program, March 1966[1]

Radiation Protection Division
Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

[1] Prepared from information and data in the April 1966 monthly report "Data from Radiation Protection Programs." Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for March 1966 are presented in table 2.

Table 2. Canadian gross beta activity in surface air and precipitation, March 1966

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	180	0.8
Coral Harbour	31	0.2	0.0	0.1	69	0.9
Edmonton	31	0.2	0.0	0.1	73	0.7
Ft. Churchill	31	0.2	0.1	0.1	23	0.6
Ft. William	31	0.2	0.0	0.1	65	3.7
Fredericton	31	0.2	0.0	0.1	28	1.9
Goose Bay	31	0.2	0.0	0.1	17	0.5
Halifax	31	0.2	0.0	0.1	30	3.5
Inuvik	31	0.2	0.1	0.1	NS	NS
Montreal	31	0.2	0.0	0.1	20	1.5
Moosonee	31	0.2	0.0	0.1	16	1.4
Ottawa	31	0.2	0.0	0.1	21	1.5
Quebec	31	0.1	0.0	0.1	23	2.9
Regina	31	0.2	0.0	0.1	139	1.0
Resolute	31	0.2	0.0	0.1	NS	NS
St. John's, Nfld	31	0.2	0.0	0.1	16	1.8
Saskatoon	30	0.2	0.0	0.1	53	0.7
Sault Ste. Marie	30	0.2	0.0	0.1	38	3.2
Toronto	31	0.2	0.0	0.1	68	3.9
Vancouver	31	0.2	0.0	0.1	28	2.6
Whitehorse	31	0.2	0.0	0.1	57	0.7
Windsor	31	0.2	0.1	0.1	53	3.3
Winnipeg	31	0.2	0.0	0.1	23	0.9
Yellowknife	31	0.2	0.1	0.1	27	0.5
Network summary		0.2	0.0	0.1	49	1.8

NS, no sample collected

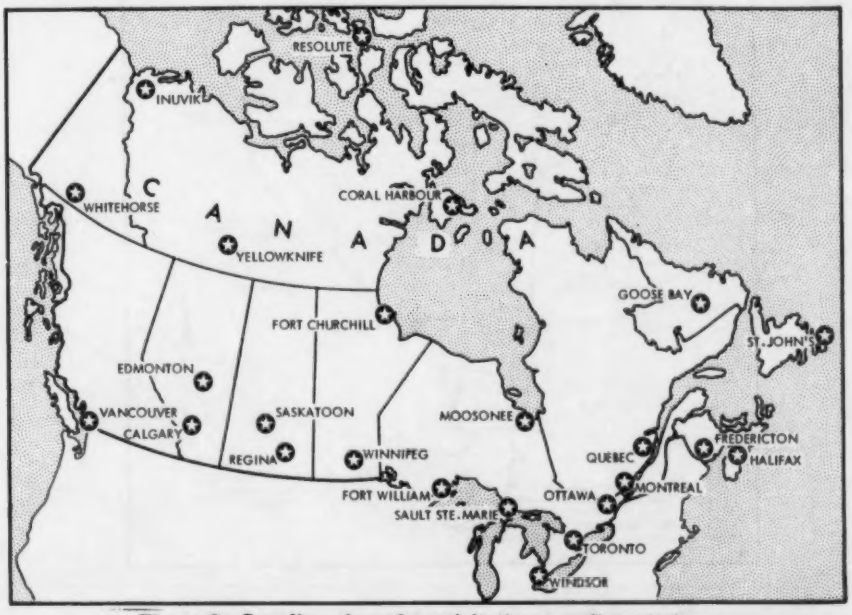

Figure 3. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program March 1966

Pan American Health Organization and U.S. Public Health Service

Gross beta activity in air is monitored by countries in the Americas, under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 4.

The March 1966 air-monitoring results from the participating countries are given in table 3.

Table 3. PAHO gross beta activity in surface air and precipitation, March 1966

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	13	<0.10	<0.10	<0.10
Chile: Santiago	28	<0.10	<0.10	<0.10
Jamaica: Kingston	24	0.12	<0.10	<0.10
Peru: Lima	25	<0.10	<0.10	<0.10
Venezuela: Caracas	21	0.13	<0.10	<0.10
West Indies: Trinidad	21	0.11	<0.10	<0.10
Pan American summary	132	0.13	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

Figure 4. Pan American Air Network sampling stations

4. National Air Sampling Network January–March 1966

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed by the NASN on their air samples is for gross beta radioactivity. NASN stations (figure 5) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operate every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data*. First quarter 1966 gross beta activities in air are given in table 4.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December and annual summary 1964	April 1965
January–March 1965	July 1965
April–June 1965	October 1965
July–September 1965	January 1966
October–December and annual summary 1965	April 1966

REFERENCES

(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products, NRL Report 6025. Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Rad Health Data 5:12–15 (January 1964).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH, RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Washington, D.C. 20201 (distribution by official request).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

Figure 5. National Air Sampling Network sampling locations, 1966

Table 4. NASN fission product gross beta activity in surface air, January–March 1966

Station name		Number of samples	Concentration, pCi/m³		
			Maximum	Minimum	Average
Ala:	Birmingham	6	0.3	0.1	0.2
	Gadsden	6	0.3	<0.1	0.1
	Mobile	6	0.2	0.1	0.2
Alaska:	Anchorage	5	0.2	<0.1	0.1
Ariz:	Grand Canyon Park *	6	0.2	<0.1	0.1
	Paradise Valley	6	0.2	0.1	0.2
	Phoenix	6	0.3	0.1	0.2
	Tucson	6	0.2	0.1	0.2
Ark:	Little Rock	6	0.2	0.1	0.1
	Montgomery County *	6	0.2	0.1	0.1
	Texarkana	5	0.2	0.1	0.2
	West Memphis	7	0.2	0.1	0.2
Calif:	Burbank	6	0.3	0.1	0.2
	Humboldt County *	6	0.1	<0.1	0.1
	Los Angeles	6	0.3	0.1	0.2
	Oakland	6	0.4	0.1	0.2
	Pasadena	6	0.2	0.1	0.1
	San Diego	5	0.1	<0.1	0.1
	San Francisco	6	0.1	<0.1	0.1
Colo:	Denver	6	0.3	0.1	0.2
	Montezuma County *	6	0.4	0.1	0.2
Conn:	Hartford	6	0.2	<0.1	0.1
	New Haven	6	0.2	<0.1	0.1
Del:	Kent County *	6	0.2	0.1	0.1
	Newark	6	0.2	0.1	0.1
	Wilmington	6	0.2	0.1	0.1
D.C:	Washington	6	0.1	0.1	0.1
Ga:	Atlanta	5	0.3	0.1	0.2
Hawaii:	Honolulu	6	0.1	0.1	0.1
Idaho:	Boise	6	0.2	0.1	0.2
	Butte County *	6	0.2	0.1	0.1
Ill:	Chicago	6	0.2	0.1	0.1
Ind:	East Chicago	6	0.2	0.1	0.1
	Hammond	6	0.1	0.1	0.1
	Indianapolis	6	0.2	0.1	0.2
	N. Monroe St. Forest *	5	0.2	0.1	0.1
	Muncie	5	0.3	0.1	0.2
	New Albany	6	0.3	0.1	0.2
	Parke County *	6	0.2	0.1	0.1
	South Bend	5	0.2	0.1	0.1
	Terre Haute	5	0.3	0.1	0.2
Iowa:	Davenport	6	0.2	0.1	0.2
	Delaware County *	6	0.2	0.1	0.1
	Des Moines	6	0.2	0.1	0.2
	Dubuque	6	0.2	0.1	0.1
Kans:	Kansas City	6	0.2	0.1	0.1
	Wichita	6	0.2	0.1	0.2
Ky:	Ashland	5	0.2	0.1	0.1
	Covington	6	0.2	0.1	0.2
	Louisville	5	0.1	0.1	0.1
La:	New Orleans	6	0.3	0.1	0.2
Maine:	Acadia Nat'l Park *	6	0.2	<0.1	0.1
	Portland	4	0.1	<0.1	0.1
Md:	Baltimore	6	0.1	0.1	0.1
	Calvert County *	6	0.1	<0.1	0.1
Mich:	Detroit	6	0.2	<0.1	0.1
Minn:	Duluth	6	0.2	0.1	0.2
	Minneapolis	6	0.2	0.1	0.1
	Moorhead	6	0.2	0.1	0.1
	St. Paul	6	0.2	0.1	0.1
Miss:	Jackson	6	0.3	<0.1	0.2
	Jackson County *	6	0.2	<0.1	0.1
Mo:	Kansas City	5	0.2	0.1	0.1
	St. Louis	5	0.2	0.1	0.1
	Shannon County *	6	0.2	0.1	0.2
Mont:	Glacier Nat'l Park *	6	0.2	<0.1	0.1
	Helena	6	0.2	0.1	0.1
Nebr:	Omaha	5	0.2	0.1	0.1
	Thomas County *	6	0.3	0.1	0.2
Nev:	Las Vegas	6	0.2	0.1	0.2
	White Pine County *	5	0.1	0.1	0.1
N.H:	Concord	6	0.2	<0.1	0.1
	Coos County *	6	0.2	<0.1	0.1
N.J:	Marlton	6	0.1	0.1	0.1
	Camden	5	0.2	0.1	0.1
	Glassboro	6	0.1	0.1	0.1
	Jersey City	5	0.2	0.1	0.1
	Newark	6	0.2	<0.1	0.1
	Perth Amboy	5	0.1	0.1	0.1
	Trenton	6	0.2	<0.1	0.1
N. Mex:	Albuquerque	6	0.3	0.1	0.2
	Rio Arriba Co.*	6	0.3	0.1	0.2
N.Y:	Cape Vincent *	5	0.1	0.1	0.1
	New York City	5	0.1	<0.1	0.1
N.C:	Charlotte	6	0.3	<0.1	0.1
	Cape Hatteras *	6	0.1	<0.1	0.0
Ohio:	Akron	6	0.3	<0.1	0.2
	Cincinnati	5	0.3	0.2	0.2
	Cleveland	6	0.2	<0.1	0.1
	Columbus	6	0.3	0.1	0.2
	Dayton	6	0.2	0.1	0.1
	Toledo	6	0.2	<0.1	0.1
	Youngstown	6	0.2	0.1	0.1
Okla:	Cherokee County *	6	0.2	0.1	0.2
	Oklahoma City	6	0.2	0.1	0.2
	Tulsa	6	0.4	0.2	0.2
Ore:	Curry County *	6	0.2	0.1	0.1
	Portland	6	0.1	<0.1	0.1
Pa:	Clarion County *	5	0.2	0.1	0.1
	Lancaster	6	0.2	0.1	0.1
	Philadelphia	6	0.1	0.1	0.1
	Pittsburgh	6	0.2	0.1	0.1
	Reading	5	0.4	0.1	0.2
	Warminster	5	0.1	<0.1	0.1
	West Chester	5	0.2	0.1	0.1
P.R:	Bayamon	6	0.2	<0.1	0.1
	Guayanilla	6	0.2	<0.1	0.1
	Ponce	6	0.2	<0.1	0.1
	San Juan	6	0.2	<0.1	0.1
R.I:	Providence	6	0.3	0.1	0.1
	Washington County *	6	0.2	<0.1	0.1
S.C:	Columbia	6	0.2	0.1	0.2
	Greenville	6	0.2	0.1	0.2
	Richland County *	6	0.2	0.1	0.2
S. Dak:	Black Hills Forest *	6	0.2	0.1	0.1
	Sioux Falls	6	0.2	0.0	0.1
Tenn:	Chattanooga	5	0.2	0.1	0.2
	Memphis	6	0.2	0.1	0.1
	Nashville	6	0.2	0.0	0.1
Tex:	Dallas	6	0.2	0.1	0.1
	Houston	6	0.2	<0.1	0.1
	Matagorda County *	5	0.2	0.1	0.1
	San Antonio	5	0.2	0.1	0.1
Utah:	Ogden	6	0.2	0.1	0.1
	Salt Lake City	5	0.2	0.1	0.1
Vt:	Burlington	6	0.2	<0.1	0.1
	Orange County *	6	0.1	<0.1	0.1
Va:	Danville	6	0.2	0.1	0.1
	Norfolk	6	0.1	<0.1	0.1
	Shenandoah Nat'l Park *	6	0.3	0.1	0.2
Wash:	Seattle	6	0.2	0.1	0.1
W. Va:	Charleston	5	0.2	0.1	0.2
Wis:	Door County *	6	0.2	0.1	0.1
	Milwaukee	5	0.1	0.1	0.1
Wyo:	Cheyenne	6	0.2	<0.1	0.1
	Yellowstone Nat'l Park *	5	0.2	0.1	0.1

* Denotes nonurban station.

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(6) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(7) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations.[1] The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[2]

Summaries of the environmental radioactivity data follow for the Paducah Plant, the Portsmouth Area Gaseous Diffusion Plant, and the Shippingport Atomic Power Station.

[1] Copies of these reports are available from the Division of Public Information, Atomic Energy Commission, Washington, D.C. 20545.

[2] Part 20, "Standards for Protection Against Radiation, AEC Rules and Regulations," contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Paducah Plant
July–December and Calendar Year 1965[3]

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant processes large quantities of relatively pure uranium compounds. A former source of diffusion plant feed, the uranium hexafluoride manufacturing plant was placed on standby in June of 1964. Parts of the associated uranium metal foundry are operated infrequently as the need arises; otherwise, it is also on standby status. A decontamination and uranium recovery facility operates to prepare equipment for repair and to recover impure or scrap uranium materials. Depleted uranium metal is fabricated into shields, weights, or ballasts, or other shapes on a nonroutine basis. The major sources of external penetrating radiation are the daughter products of uranium, thorium–234, and protactinium–234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

[3] Summarized from "Environmental Concentrations of Radioactive Materials Near the Paducah Plant Report for the Year and for the Second Half of 1965."

Because uranium is a rather expensive element, as much of it is recovered as is feasible. The added desire to maintain a wholesome relationship with neighboring communities and individuals makes it essential that entrained dust be filtered from exhaust systems, and that all effluent waters be maintained at extremely low concentrations of uranium.

An environmental monitoring system checks the effectiveness of the confinement and recovery systems of the plant. The environmental monitoring program provides for continuous sampling of the air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 1). Air is filtered at 0.3 cubic feet per minute through 2-inch-diameter membrane filters which are replaced weekly and counted for alpha and beta activity. Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air-sampling stations with a Geiger-Mueller type meter at a distance of 3 feet above ground level.

Basic standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those listed in the AEC manual.

The standards specify that the radiation or radioactive materials outside a controlled area which have resulted from operations within the controlled area shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion of data

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 1 through 4.

The average alpha counts—interpreted as uranium, the most likely source of activity—of the 234 air samples collected during the second half of 1965, and of the 468 air samples collected during calendar year 1965, were both 1 percent of the concentration limit for people residing in the vicinity of a controlled area. The mean beta counts of the same samples were

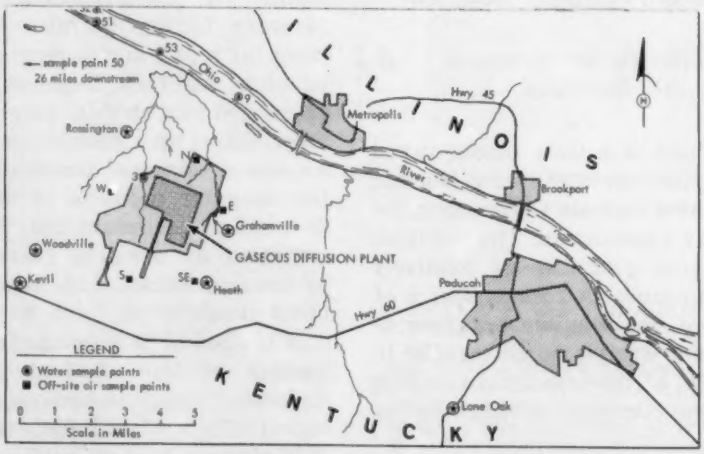

Figure 1. Sampling locations, Paducah Gaseous Diffusion Plant

Table 1. Uranium concentrations in outdoor air samples Paducah Plant, 1965

Sample location [a]	Number of samples	Uranium alpha [b] (pCi/m³)			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
January–June, 1965					
At plant perimeter fence					
North	26	0.13	<0.02	0.03	1
East	26	0.16	<0.02	0.02	1
South	26	0.11	<0.02	0.02	1
West	26	0.08	<0.02	0.02	1
Totals	104	0.16	<0.02	0.02	1
About 1 mile outside plant perimeter fence					
North	26	0.05	<0.02	0.02	1
East	26	0.07	<0.02	0.02	1
South	26	0.07	<0.02	0.02	1
West	26	0.10	<0.02	0.02	1
Southeast	26	0.09	<0.02	0.02	1
Totals	130	0.10	<0.02	0.02	1
July–December, 1965					
At plant perimeter fence					
North	26	0.13	<0.02	0.02	1
East	26	0.38	<0.02	0.03	1
South	26	0.10	<0.02	0.02	1
West	26	0.13	<0.02	0.02	1
Totals	104	0.38	<0.02	0.02	1
About 1 mile outside plant perimeter fence					
North	26	0.09	<0.02	0.02	1
East	26	0.11	<0.02	0.02	1
South	26	0.12	<0.02	0.02	1
West	26	0.08	<0.02	0.02	1
Southeast	26	0.08	<0.03	0.02	1
Totals	130	0.12	<0.02	0.02	1
Calendar year, 1965					
At plant perimeter fence					
North	52	0.13	<0.02	0.03	1
East	52	0.38	<0.02	0.02	1
South	52	0.11	<0.02	0.02	1
West	52	0.13	<0.02	0.02	1
Totals	208	0.38	<0.02	0.02	1
About 1 mile outside plant perimeter fence					
North	52	0.09	<0.02	0.02	1
East	52	0.11	<0.02	0.02	1
South	52	0.12	<0.02	0.02	1
West	52	0.10	<0.02	0.02	1
Soutleast	52	0.09	<0.02	0.02	1
Totals	260	0.12	<0.02	0.02	1

[a] See figure 1.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 alpha dis/sec.
[c] The minimum detectable concentration of uranium in air is 0.02 pCi/m³.
[d] The concentration limit for natural uranium in air released to the environs is 2 pCi/m³.

0.02 percent and 0.03 percent of the concentration limit, respectively. Due to a clerical error at the Paducah Plant, certain values for the first half of 1965 were incorrectly reported in the January issue of *Radiological Health and Reports*. The correct values are reported in tables 1 and 2.

The averages of uranium analyses of weekly water samples collected by a continuous water sampler in Big Bayou Creek for the second half of 1965 and the calendar year 1965, were both 0.05 percent of the concentration limit for water beyond a controlled area. The results of the uranium analyses for each of the 12 grab samples collected each month from the Ohio River below the plant were less than 0.01 percent of the concentration limit.

The concentration of beta emitters in Big Bayou Creek averaged less than 0.5 percent of the concentration limit for the decay products of uranium–238 during the second half of 1965; the average for the year was 0.5 percent of the concentration limit. The beta activity of the Ohio River was at or below the minimum detectable level during the second half of 1965, and the results of all samples during the year averaged 0.5 percent of the concentration limit for uranium–238 decay products.

Table 2. Beta concentrations in outdoor air samples Paducah Plant, 1965

Sample location [a]	Number of samples	Beta, pCi/m³			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
January–June 1965					
At plant perimeter fence					
North	26	1.6	0.2	0.6	0.06
East	26	1.0	0.1	0.4	0.04
South	26	0.8	0.1	0.4	0.04
West	26	1.0	<0.1	0.4	0.04
Totals	104	1.6	<0.1	0.4	0.05
About 1 mile outside plant perimeter fence					
North	26	1.1	0.15	0.4	0.04
East	26	0.9	0.11	0.4	0.04
South	26	1.0	0.16	0.4	0.04
West	26	1.0	0.13	0.4	0.04
Southeast	26	0.9	0.20	0.4	0.04
Totals	130	1.1	0.11	0.4	0.04
July–December 1965					
At plant perimeter fence					
North	26	0.4	<0.1	0.2	0.02
East	26	1.2	<0.1	0.2	0.02
South	26	0.4	<0.1	0.1	0.01
West	26	0.5	<0.1	0.1	0.01
Totals	104	1.2	<0.1	0.1	0.02
About 1 mile outside plant perimeter fence					
North	26	0.6	<0.1	0.2	0.02
East	26	0.5	<0.1	0.2	0.02
South	26	0.4	<0.1	0.2	0.02
West	26	0.6	<0.1	0.2	0.02
Southeast	26	0.6	<0.1	0.2	0.02
Totals	130	0.6	<0.1	0.2	0.02
Calendar year 1965					
At plant perimeter fence					
North	52	1.6	<0.1	0.4	0.04
East	52	1.2	<0.1	0.3	0.03
South	52	0.8	<0.1	0.3	0.03
West	52	1.0	<0.1	0.3	0.03
Totals	208	1.6	<0.1	0.3	0.03
About 1 mile outside plant perimeter fence					
North	52	1.1	<0.1	0.3	0.03
East	52	0.9	<0.1	0.3	0.03
South	52	1.0	<0.1	0.3	0.03
West	52	1.0	<0.1	0.3	0.03
Southeast	52	0.9	<0.1	0.3	0.03
Totals	260	1.1	<0.1	0.3	0.03

[a] See figure 1.
[b] The minimum detectable amount of beta emitters in air is 0.1 pCi/m³.
[c] The concentration limit applicable to this table is 1,000 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

Table 3. Concentration of uranium in water, Paducah Plant, July–December 1965 and calendar year 1965

Sample location [a]	Number of samples	Uranium, pCi/liter [b]			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
July–December 1965					
Big Bayou Creek 3	26	33	<1	10	0.05
Ohio River 9	6	1	<1	<1	<0.01
Composite of 50, 51, 52, and 53	6	2	<1	<1	<0.01
Calendar year 1965					
Big Bayou Creek 3	52	33	<1	9	0.05
Ohio River 9	12	1	<1	<1	<0.01
Composite of 50, 51, 52, and 53	12	2	<1	<1	<0.01

[a] See figure 1.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 dis/sec.
[c] The minimum detectable uranium in water is 1 pCi/liter.
[d] The concentration limit for natural uranium in water beyond a controlled area is 20,000 pCi/liter.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hour at all sampling stations in 1965.

Table 4. Concentration of beta emitters in water, Paducah Plant, July–December and calendar year 1965

Sample location [a]	Number of samples	Beta emitters (pCi/liter)			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
July–December 1965					
Big Bayou Creek 3	26	100	<100	<100	<0.5
Ohio River 9	6	100	<100	<100	<0.5
Composite of 50, 51, 52, and 53	6	700	<100	200	1
Calendar year 1965					
Big Bayou Creek 3	52	2,200	<100	100	0.5
Ohio River 9	12	700	<100	100	0.5
Composite of 50, 51, 52, and 53	12	700	<100	100	0.5

[a] See figure 1.
[b] The minimum detectable amount of beta emitters in water is 100 pCi/liter.
[c] The concentration limit for the daughter products of uranium in water released to the environs in 20,000 pCi/liter.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	January 1962
July–December 1961	August 1962
1962	September 1963
1963	July 1964
January–June 1964	February 1965
1964	July 1965
January–June 1965	January 1966

2. Portsmouth Area Gaseous Diffusion Plant July–December 1965 [4]

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium–234 are the radionuclides most likely to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium–234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

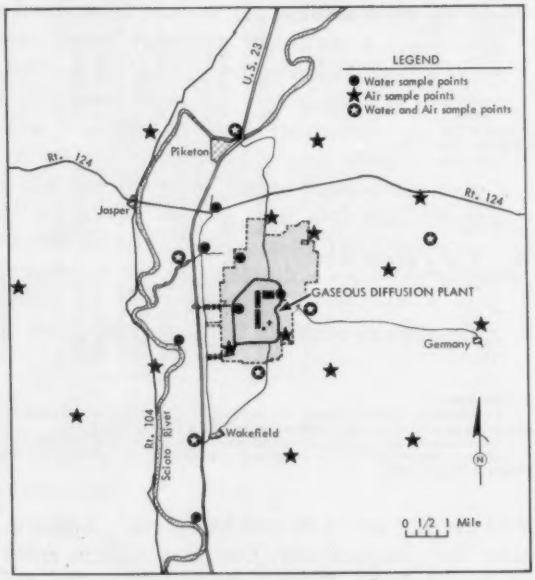

Figure 2. Air sampling locations, Portsmouth Area Gaseous Diffusion Plant

Continuous air samples are collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 2. Monthly water samples are collected at 13 stations within 5 miles of the plant.

[4] Data summarized from B. Kalmon: "Environmental Radiation Levels and Concentrations, Second Half and Annual Summary 1965," GAT 506 (February 18, 1966).

For the second half of 1965, both the airborne alpha and the beta-gamma activity dropped significantly compared to the first half of 1965. The alpha airborne average for the second half of the calendar year dropped from 16.1 percent to 9.7 percent of the concentration limit. The beta-gamma concentration was less than 0.01 percent, compared to 0.05 percent for the first half.

During the last half of 1965, the average alpha concentration in the water effluents increased, while the beta-gamma activity decreased. In July and August, higher than usual concentrations of radioactivity were detected in water at sample point 11. The highest individual results for alpha and beta-gamma were 12 and 18 percent, respectively, of the concentration limit. Point 11 receives the direct discharge of an effluent holding pond prior to additional dilution and prior to leaving the plant boundaries.

Annual background exposure rates continued to decline in 1965, decreasing from 48 percent to 22.8 percent of the permissible exposure limits in the past year. The second half of 1965 was also lower than the first half of 1965. In the calculations it is assumed that all of the exposure rates are attributable to plant operations. As in the past, the offsite and onsite patterns are very much alike in form and intensity, with no significant differences between the average values. From the onsite and offsite intensities and the continuing decline in exposure rates which followed the moratorium in nuclear testing activities, it is evident that the plant operations have not added appreciably to the general background radiation.

Average alpha and beta-gamma concentrations in air and water are summarized in table 5. The external gamma levels, measured at the air-sampling locations shown in figure 2, are also summarized in table 5. The overall average concentrations and background exposure rates for July to December 1965 are presented in table 6, along with the values for the first half of 1965 and the calendar years 1964 and 1965.

Table 5. Environmental radioactivity, Portsmouth Plant July–December 1965

Type of monitoring	Number of samples	Maximum	Minimum	Average	Average as percent of concentration limit [a]
Air					
Alpha concentration pCi/m³	89	0.9	<0.1	0.2	9.7
Beta-gamma concentration pCi/m³	89	0.9	<0.1	<0.1	<0.01
Water					
Alpha concentration pCi/liter	61	2,610	<0.5	90.4	0.45
Beta-gamma concentration pCi/liter	62	1,035	<14.0	35.4	0.18
External beta-gamma [b] mrad/hr	91	0.04	0.01	0.02	24

[a] The applicable concentration or exposure limits are as follows:

Air (alpha)	2 pCi/m³
(beta-gamma)	1,000 pCi/m³
Water (alpha)	20,000 pCi/liter
(beta-gamma)	20,000 pCi/liter
External beta-gamma	500 mrad/yr (approximately 0.06 mrad/hr)

[b] Measurements were made with open shield Geiger-Mueller tube 1 foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration limit.

Table 6. Comparison of average concentrations Portsmouth Plant

Type of monitoring	Percent of concentration or exposure limit [a]			
	1964	1965		
	Calendar year	First half	Second half	Calendar year
Air				
Alpha concentration	5.0	16.1	9.7	13.8
Beta-gamma concentration	0.15	0.05	<0.01	0.03
Water				
Alpha concentration	0.07	0.19	0.45	0.30
Beta-gamma concentration	<0.07	0.49	0.18	0.32
Overall background exposure extrapolated to 3 feet above ground	48	30	24	28

[a] See footnote (a) of table 5.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
First and second quarters 1961	February 1962
Third and fourth quarters 1961	September 1962
1962	May 1963
1963	July 1964
January–June 1964	February 1965
1964	July 1965
January–June 1965	January 1966

3. Shippingport Atomic Power Station July–December 1965[5]

Duquesne Light Company
Shippingport, Pennsylvania

The Shippingport Atomic Power Station is operated for the Atomic Energy Commission by the Duquesne Light Company. The plant site is located near Shippingport, Pennsylvania, along the Ohio River about 25 miles northwest of Pittsburgh.

The pressurized water reactor with core 1 ("seed and blanket" design) achieved full power on December 23, 1957, and has operated continuously except for shutdowns which were necessary for maintenance and "seed" refueling. In February 1964, the reactor was shut down for the replacement of core 1 with core 2, the decontamination of the primary system, and the commencement of other associated reactor plant modifications. The reactor remained shut down until April 1965, at which time operations were resumed.

A monitoring program was begun 2 years before plant startup to determine the background levels of radioactivity in the environment. This program was continued after plant startup to ensure that radioactive waste discharges from normal plant operations do not cause significant changes in these levels in the plant environment. The present program of monitoring consists of measurements of radioactivity in air, fallout, and Ohio River water. Figure 3 shows the sampling locations.

Liquid radioactive waste disposal

The concentration limits for the discharge of radioactive wastes at Shippingport are based on a knowledge of the radionuclide mixture making up the waste and on the radiation protection standards of Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524; and Chapter 4, Article 433 of the Rules and Regulations, Commonwealth of Pennsylvania Department of Health. The discharge of tritium, one of the less hazardous radionuclides, is controlled separately, based on its own limit. The liquid effluent from the plant radioactive waste disposal system is carefully monitored before, during, and after release to the Ohio River to ensure that the concentration limits recommended by the above regulations are not exceeded.

The liquid radioactive wastes discharged during the second half of 1965 are summarized below. The monthly average concentrations of gross radioactivity shown in table 7 include normal background radioactivity and are calculated after total radioactive waste discharges are diluted in the condenser cooling water effluent channel. The maximum total discharge, exclusive of tritium, in 1 day during the second half of 1965, was 4.65 mCi.

Table 7. Total radioactive waste, exclusive of tritium, discharged into the Ohio River during 1965

Period	Total discharge (mCi)	Average discharge per day (mCi)	Average concentration effluent channel (pCi/liter)
July	6.11	0.197	1.75
August	4.09	0.132	1.07
September	4.15	0.138	1.00
October	16.67	0.538	5.48
November	16.83	0.561	5.52
December	15.38	0.496	0.82
Total second half	63.2	0.344	1.74
Total first half	74.4	0.65	3.86
Total 1965	138	0.50	2.48

Table 8 is a summary of the tritium that was discharged into the Ohio River, the monthly average concentration of tritium in the hold-up tanks prior to discharge, and the monthly average concentration of waste in the effluent channel after dilution with the condenser cooling

Table 8. Tritium released to Ohio River during 1965

Period	Total discharge (mCi)	Average discharge (mCi)	Average concentration in holdup tank (pCi/liter)	Average concentration in effluent channel (pCi/liter)
July	227	7.32	1,510,000	115
August	135	4.35	5,100,000	85
September	190	6.34	1,690,000	195
October	626	20.2	2,660,000	716
November	867	28.9	3,380,000	420
December	916	29.6	3,540,000	50
Total second half	2,961	16.1	2,840,000	115
Total first half	81	0.447	520,000	10.9
Total 1965	3,042	8.34	1,680,000	88.8

[5] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the Second Half of 1965 and Calendar Year 1965," PNRO–SMD–137.

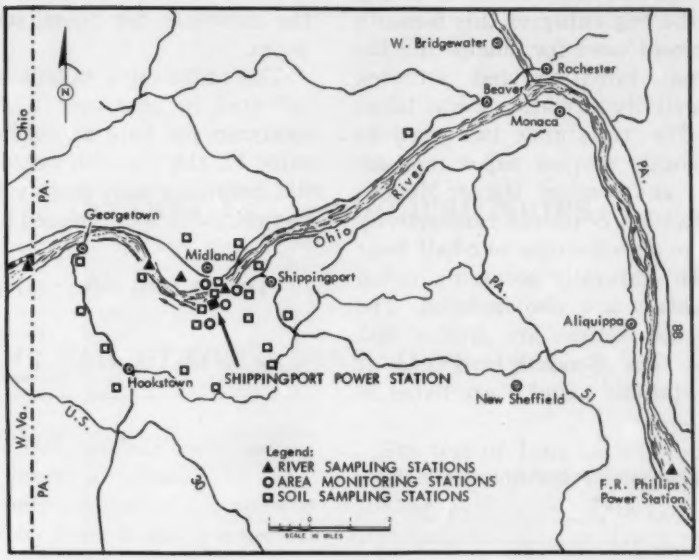

Figure 3. Shippingport power station sampling locations

water. The maximum tritium discharged in 1 day during the second half of 1965 was 131 mCi. Automatic samplers are installed at the station's river water influent and effluent to collect river water samples continuously for comparative purposes.

Since the effluent sampler was inoperative during this report period, daily grab samples were collected. Weekly composites of the daily grab samples and continuous samples were analyzed for gross beta and gross alpha radioactivities in the suspended and dissolved solids. The potassium–40 radioactivity in the total solids of these samples was also measured. No significant difference was observed between the average alpha, beta, and potassium–40 radioactivity in the upstream and downstream samples. The results of these analyses are shown in table 9.

Table 9. Gross radioactivity in the Ohio River during 1965

Type of radioactive material	Concentration, pCi/liter					
	Upstream samples			Downstream samples		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha						
Second half						
Suspended	0.98	0.02	0.20	3.71	0.03	0.30
Dissolved	5.20	0.33	1.13	4.75	0.33	1.27
Total	5.48	0.37	1.33	5.34	0.25	1.57
First half—total			1.78			1.56
Calendar year—total			1.56			1.57
Beta						
Second half						
Suspended	23.5	0.63	4.16	53.5	0.65	7.66
Dissolved	26.8	0.83	10.18	52.4	3.31	13.46
Total	50.3	4.77	14.34	73.2	4.32	21.12
First half—total			18.77			19.02
Calendar year—total			16.56			20.07
Potassium-40						
Second half—total	11.6	2.30	7.80	11.3	2.10	7.80
First half—total			3.75			4.10
Calendar year—total			5.78			5.95

Atmospheric release of radioactive materials

During the second half of 1965, a total of 32.7 mCi of xenon–133 was released from Shippingport at concentrations less than the limit of 300,000 pCi/m³. The incinerator, which is used for burning contaminated, combustible waste, was not operated.

Environmental monitoring

Three area monitoring stations are normally used to collect fallout, to detect and record levels of external beta-gamma radiation, and to detect and record levels of airborne particulate radioactivity in the power station vicinity. Stations 1, 2, and 3 are located 150

yards southeast, 150 yards west, and one-half mile north-northwest of the reactor building, respectively. At the beginning of this 6-month period, the equipment used for monitoring the levels of external radiation and airborne particulate radioactivity at station 2 was taken out of service. The remaining two stations include a continuously moving paper tape air sampler with an end-window Geiger-Mueller detector and a recorder. Since the radioactivity is measured by the detector only one-half hour after its collection, naturally occurring radon and thoron daughters are also included. The data collected by the stations are checked and averaged weekly. The 6-month averages of these data from stations 1 and 3 are listed in table 10.

Table 10. Airborne particulate radioactivity during 1965

Station number and period	Percent of time not working	Average concentration, pCi/m³		
		Maximum	Minimum	Average
1				
Second half	69	9.03	0.0785	2.12
First half				1.40
Calendar year				1.76
2				
Second half	100			
First half				2.52
Calendar year				2.52
3				
Second half	0	7.85	0.0785	1.71
First half				1.10
Calendar year				1.40

External beta-gamma radiation levels at each station are continuously measured and recorded by a Geiger-Mueller detector and a recorder. The data collected at each station are checked and averaged weekly. The results of these measurements, as shown in table 11, indicate that the radiation levels for stations 1 and 3 were not significantly different from the averages for these stations for previous years.

Table 11. Beta-gamma background radiation levels during 1965

Station number and period	Percent of time not working	Radiation levels, mR/hr		
		Maximum	Minimum	Average
1				
Second half	8	0.420	0.006	0.013
First half				0.016
Calendar year				0.015
2				
Second half	100			
First half				0.14
Calendar year				0.14
3				
Second half	0	0.059	0.011	0.021
First half				0.022
Calendar year				0.022

The radioactive fallout at each station was collected in pots over a 1-month period and analyzed for beta radioactivity. As shown in table 12, the 6-month averages for the stations did not differ significantly to indicate that any radioactivity was released by the power station.

Table 12. Beta radioactivity in fallout during 1965

Station number and period	Deposition rate, nCi/m²/month		
	Maximum	Minimum	Average
1			
Second half	7.16	1.79	4.28
First half			23.9
Calendar year			14.9
2			
Second half	6.78	2.55	4.21
First half			20.8
Calendar year			12.6
3			
Second half	7.60	3.89	4.40
First half			19.9
Calendar year			12.2

Average for all stations—second half—4.28 nCi/m²/month.

Summary

During the second half of 1965, measurements of radioactivity were made in the Ohio River and the atmosphere in the vicinity of the Shippingport Atomic Power Station. The results of these measurements indicate that the radioactive material released by the power station into the air and into the Ohio River did not result in a significant change in the existing levels of radioactivity in the environment.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	April 1962
July 1962–June 1963	March 1964
July–December 1963	November 1964
Calendar Year 1964	August 1965
January–June 1965	February 1966

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, JUNE 1966

Five underground U.S. nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission during June 1966. The tests conducted on June 2 and 3 were of low-intermediate yield (force equivalent to 20–200 kilotons of TNT); tests conducted on June 10 and 25 were of low yield (force equivalent of up to 20 kilotons of TNT); and the test conducted on June 30 was of intermediate yield (force equivalent to 200 kilotons to 1 megaton of TNT).

The test of June 25 was part of the "Plowshare Program" to develop peaceful uses for nuclear explosives. This test was part of an experimental effort to develop a special nuclear device capable of producing in a nuclear explosion neutron-rich isotopes of the known transplutonium elements and, possibly, of new, heavier elements.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

TRITIUM IN SURFACE WATERS, 1964–1965. *M. W. Chesnutt, J. C. Drobinski, Jr.,* and *R. H. Gorrie* (U.S. Public Health Service). *Radiological Health Data and Reports,* Vol. 7, July 1966, pp. 377–380.

Concentrations of tritium in U.S. surface waters are reported for the period of May 1964 through December 1965. This is the initial report of a continuing surveillance program. The results show some differences in tritium concentrations in water samples from various parts of the country and as a function of time. The highest level observed (20.3 nCi/liter) is well below the occupational exposure guide (30 μCi/liter) and the guidance level requiring active surveillance (100 nCi/liter), calculated from the general guidance of the Federal Radiation Council.

KEY WORDS: environment, exposure, guides, nuclear facilities, river systems, surface waters, tritium.

STRONTIUM–90 IN 1965 UNITED STATES WHEAT. *R. A. Anderson* and *V. F. Pfeifer* (U.S. Department of Agriculture). *Radiological Health Data and Reports,* Vol. 7, July 1966, pp. 381–382.

In continuing surveys of strontium–90 levels in wheat, USDA studies indicate the U.S. weighted average concentration to be 95 pCi/kg, which compared well with the Federal Radiation Council's prediction for 1965 (88 pCi/kg). The 1965 average also confirms the predicted continuing downward trend seen in 1963 and 1964 averages—220 and 133 pCi/kg, respectively. Samples used to develop the 1965 average represented 52 percent of the U.S. wheat production; and individual strontium–90 concentrations ranged from a low of 31 pCi/kg, in soft white winter wheat from Washington, to a high of 174 pCi/kg in hard red winter wheat from Kansas. It was noted that the 1965 trends of high and low concentrations were similar to those of 1964.

KEY WORDS: milled products, sampling, strontium–90, survey, United States, wheat.

STRONTIUM–90 IN HUMAN BONE FROM INFANCY TO ADULTHOOD, 1962–1963. *G. W. Gaffney, R. M. Hallisey, M. S. Miller,* and *E. J. Baratta* (Division of Radiological Health). *Radiological Health Data and Reports,* Vol. 7, July 1966, pp. 383–386.

Strontium–90 accumulation in the bones of children and adults through age 25 is analyzed by comparing the strontium–90 to calcium ratios found in specimens from selected age groups during the 1962–1963 portion of a continuing program. The highest mean strontium–90 to calcium ratios were found in the 1- to 4-year olds, with the 1962 peak in the 1-year olds (4.5 pCi/g) and the 1963 peak in the 2-year olds (5.6 pCi/g). It is pointed out that the mean values for the group under 1 year of age were relatively low (2.6 pCi/g in 1962; 1.8 pCi/g in 1963), but were obtained from a small number of samples. Average strontium–90 to calcium ratios in bone of older groups declined with increasing age and were least in the 20- to 25-year-age group. The data for each age group, although limited, appear to follow a log normal distribution, and it is suggested that this distribution is more suitable than a normal distribution as a basis for calculating the proportion of a population group in which a given body burden is unlikely to be exceeded.

KEY WORDS: adults, body burden, bone, children, human log normal distribution, population, strontium–90/calcium ratio.

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SYMBOLS, UNITS, AND EQUIVALENTS

Symbols	Units	Equivalents
BeV	billion electron volts	equals GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volts	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mī' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

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